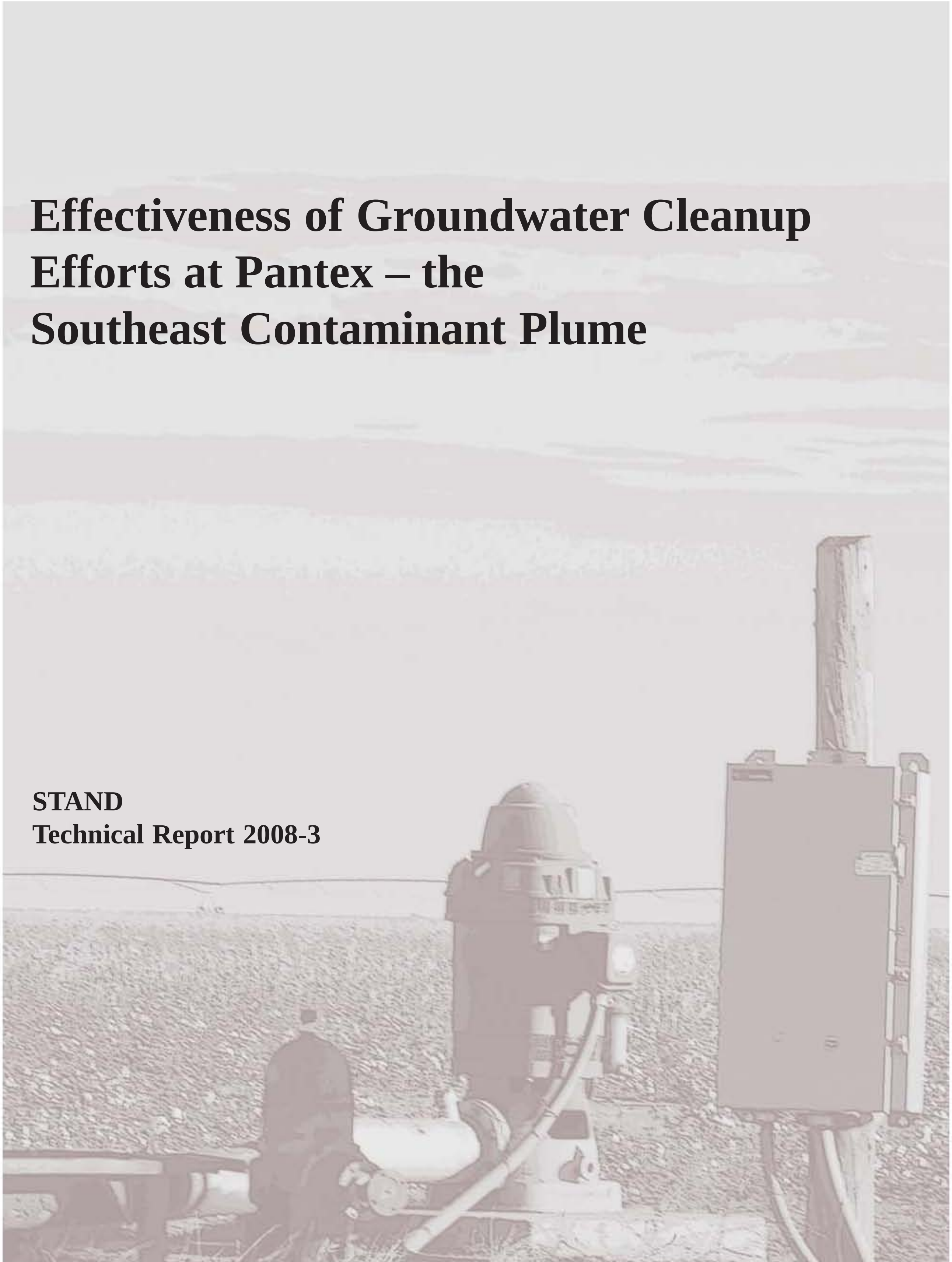

Effectiveness of Groundwater Cleanup Efforts at Pantex – the Southeast Contaminant Plume

STAND
Technical Report 2008-3

Effectiveness of Groundwater Cleanup Efforts at Pantex - the Southeast Contaminant Plume

Prepared for STAND

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Executive Summary

This is an evaluation of the U. S. Department of Energy's (DOE) plans to cleanup contaminated groundwater in the southeast portion of the perched aquifer at the Pantex plant. The major findings are:

1. Contaminants detected in the perched aquifer include high explosives (e.g., HMX, RDX, TNT), metals (e.g., boron, chromium), and solvents (e.g., TCE, PCE).

2. The groundwater contaminants came primarily from industrial wastewater discharged to ditches and playas. Large amounts of contaminated water remain in the vadose zone above the perched aquifer. DOE estimates that this contaminated water will continue to drain to the perched aquifer for the next 150 to 200 years.

3. Contaminated groundwater is flowing downward from the perched aquifer, toward the Ogallala Aquifer, at a rate of approximately 70 million gallons per year.

4. DOE plans to remove contaminants from the perched aquifer with pump and treat, and in-situ bioremediation systems. The primary objectives of the cleanup are to 1) restore groundwater in the perched aquifer to health-based standards, and 2) prevent contaminants from reaching the Ogallala Aquifer in concentrations that would cause an exceedance of drinking water standards.

5. The existing pump and treat system has been only marginally effective in cleaning up contaminants in the perched aquifer. It has removed only a small portion of the RDX that exists in the perched aquifer and overlying vadose zone. RDX concentrations in most monitor wells in the vicinity of the system remain well above the 2.0 µg/L cleanup level. RDX concentrations in a number of monitor wells are increasing.

6. Under the cleanup plan proposed by DOE, water in the perched aquifer will remain contaminated for the foreseeable future.

1.0 Introduction

This is an evaluation of the effectiveness of the U. S. Department of Energy's (DOE) efforts to cleanup groundwater contaminants in the southeast portion of the perched aquifer at Pantex[1]. It was performed on behalf of STAND, an organization of concerned citizens.

The Pantex plant is 17 miles northeast of Amarillo, Texas (figure 1.1). It occupies 15,940 acres[2]. During World War II the U.S. Army produced conventional shells and bombs at the plant. Since the early 1950s Pantex has been operated by the DOE and its predecessor agencies as a facility to assemble and disassemble nuclear weapons, and to fabricate and test chemical explosives[3]. The plant contains buildings and industrial structures, a wastewater treatment plant[4], landfills, waste disposal pits, borrow pits, and agricultural lands[5]. There are three playas on the plant-site, and two playas on the Texas Tech Research Farm immediately south of the plant (figure 1.2).

2.0 Overview of Stratigraphy, Groundwater Systems and Groundwater Contamination

2.1 Stratigraphy

The uppermost stratigraphic unit at Pantex is the Blackwater Draw Formation (figure 2.1). This is a 50 to 80 feet thick sequence of wind-deposited clays, silts, and sands. It does not contain bodies of groundwater. The Blackwater Draw is underlain by the Ogallala Formation, a sequence of clays, silts, sands, and gravels. The thickness of the Ogallala ranges from 315 to 820 feet[6]. There are two water-bearing zones in the Ogallala: a perched aquifer, and the main Ogallala Aquifer[7]. The unsaturated[8] materials between land surface and the water table of the perched aquifer constitute an upper vadose zone[9]. The unsaturated materials between the bottom of the perched aquifer and the water table of the main Ogallala Aquifer constitute a lower vadose zone. The Ogallala is underlain by the Dockum Group, a sequence of shale, siltstone, and sandstone.

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[1] This is an update and expansion of appendix B in STAND, 2008a. This report focuses on contaminants in the southeast portion of the main perched aquifer. Information on contaminants in the Ogallala Aquifer and other portions of the perched aquifer can be found in other documents (e.g., BWXT 2007a, STAND 2008a).
[2] Battelle 1997, page 5.
[3] DOE 1998a, page 2-1.
[4] The treatment plant receives both sewage and industrial effluent. DOE, 2000i, page 2-8.
[5] DOE 2000h, pages 2-11 and 4-2.
[6] BWXT 2007b, page 2-6.
[7] Battelle 1997, pages 10 & 11.
[8] Unsaturated zone: a zone where the void spaces are not completely filled with water or some other liquid.
[9] Vadose zone: the unsaturated zone plus the capillary fringe immediately above the water table. The capillary fringe may be saturated.

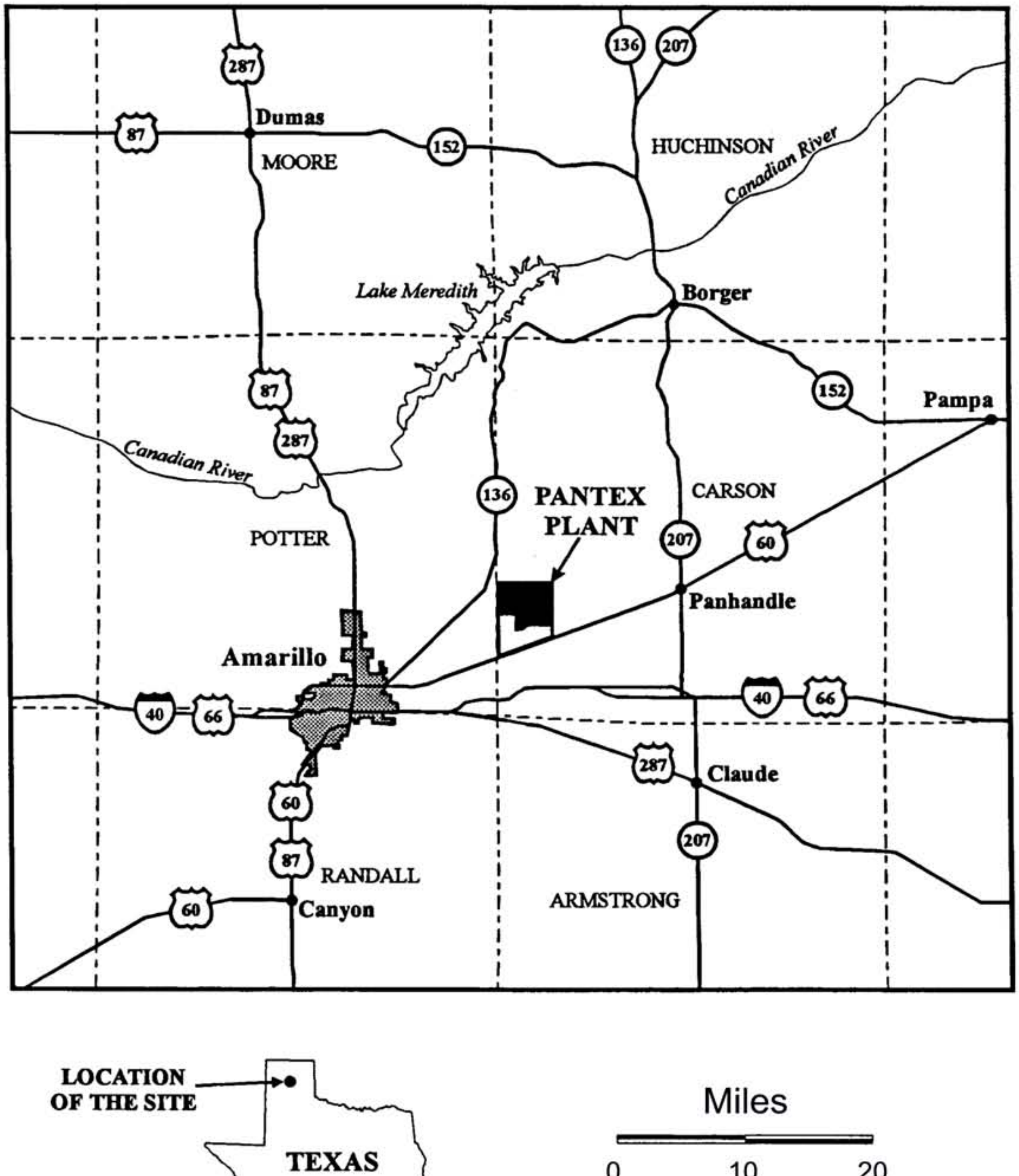

Figure 1.1
Pantex Plant Location
Adapted From Battelle, 1997

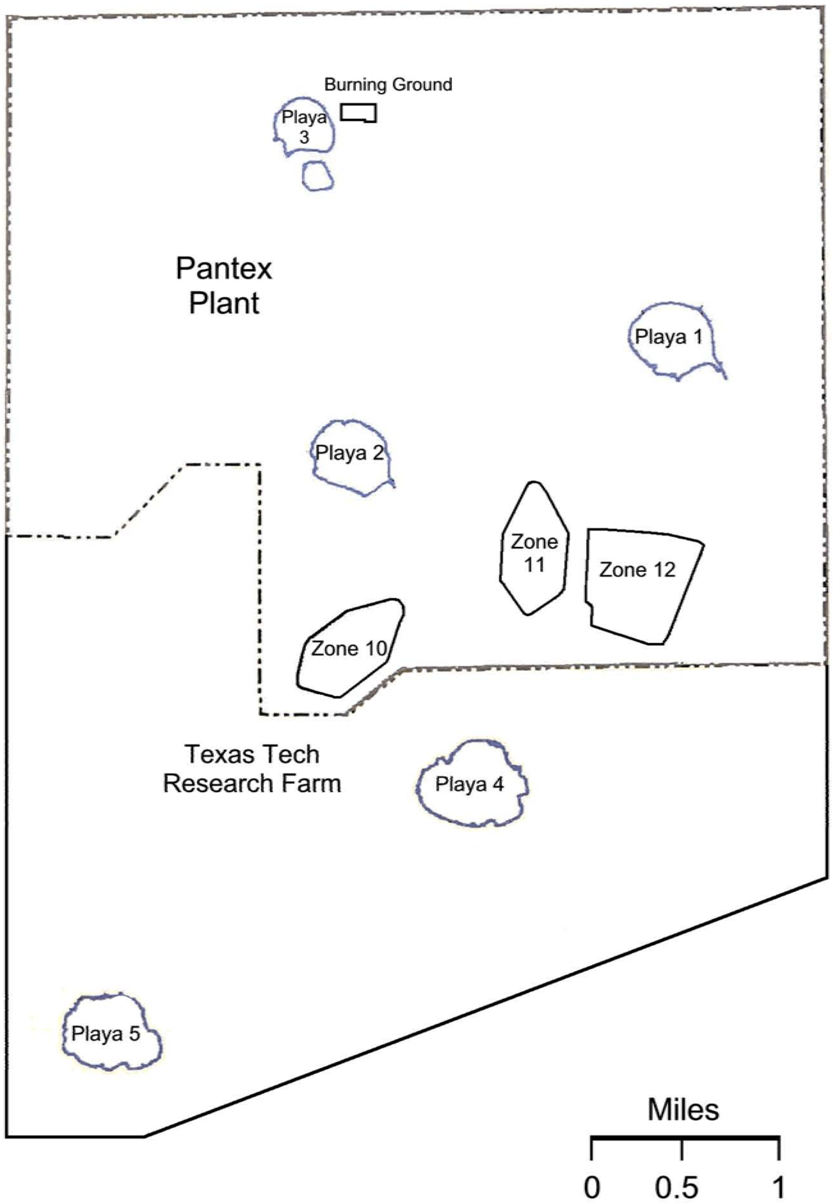

Figure 1.2
Pantex Plant

Adapted from BWTX 2007b, figure 1-1

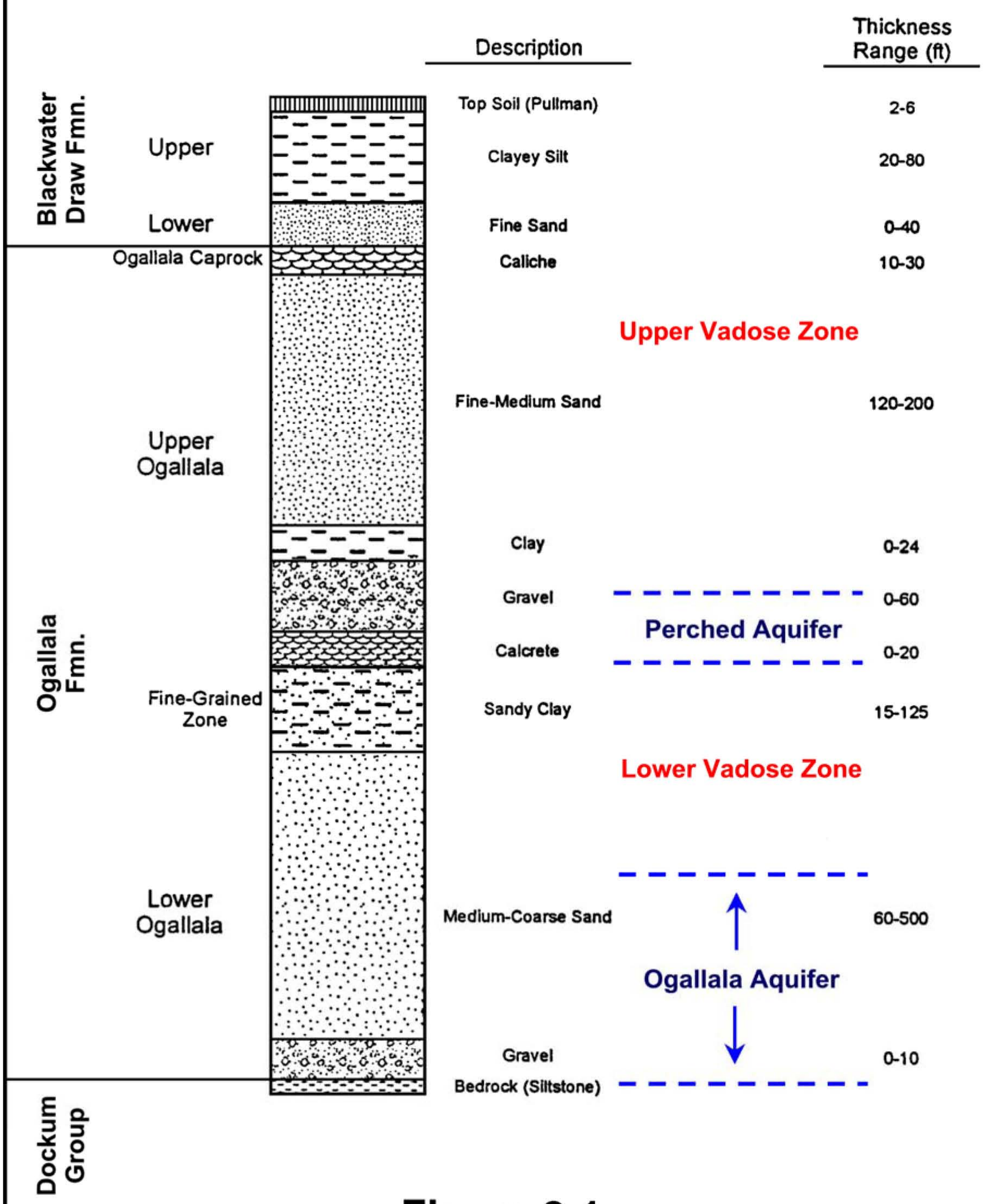

Figure 2.1
Geologic Column at Pantex

Adapted from Battelle, 1997

2.2 Perched Aquifer

The perched aquifer at Pantex is found at depths ranging from 195 to 300 feet below land surface[10]. The average saturated thickness of water in the perched aquifer is about 22 feet and the maximum thickness is about 80 feet[11]. The saturated thickness along the edge of the perched aquifer is zero.

The perched aquifer does not exist beneath all of Pantex. There are at least four bodies of perched groundwater (figure 2.2)[12]: 1) groundwater associated with landfills in the west-central portion of the plant, 2) groundwater associated with Playa 3 in the northern portion of the plant, 3) groundwater associated with Pratt Playa in the northeastern portion of the plant, 4) the main body of perched groundwater. The main body extends across approximately 11 square miles in the central, southern, and southeastern portions of the plant. It also extends offsite beyond the eastern and southern boundaries of the plant[13].

Groundwater in the perched system eventually drains downward to recharge the underlying Ogallala Aquifer. Modeling performed by DOE indicates that groundwater is draining from the perched aquifer at a rate of approximately 70 million gallons per year[14].

2.3 Sources of Contamination

Operations at Pantex have caused contamination of soils, groundwater, and the vadose zone. In the past, industrial wastes were discharged to the three playas on Pantex as well as the two playas on the Texas Tech Research Farm[15]. Wastewaters containing explosives, pesticides, metals, PCBs, and volatile organic compounds were discharged to playas via unlined ditches[16]. The contaminated water percolated downward through the vadose zone, to the perched aquifer.

Pantex also contains many waste disposal and accident (e.g., spills, leaks) sites that may have contaminated groundwater[17]. These include solvent disposal trenches, a solvent evaporation pit, sludge beds, unlined burn pits, subsurface leaching beds, pesticide rinse areas, leaking underground storage tanks, unlined landfills, waste drum storage areas, solvent leak sites, acid spill sites, a transformer leak site, and a

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[10] BWXT 2007b, page 2-6.
[11] BWXT 2007a, page 9-5.
[12] Stoller 2001, figure 2-15. Note: it is sometimes difficult to determine the presence of the perched aquifer. The dry zone shown near Zone 11 may have been identified based on wells that were screened in the fine-grained zone. See Battelle, 1997, page 40.
[13] BWXT 2007a, page 9-6 and figure 9-3.
[14] BWXT 2007a, page 9-6.
[15] Battelle 1997, page 8. The wastes discharged to Playa 5 came from the Amarillo Air Base and were used as a source of irrigation water. Wastes were accidentally discharged to Playa 3; the Burning Ground solvent evaporation pit overflowed and the wastes ran into Playa 3 (DOE 2008a, page 4).
[16] DOE 1999a, page 6. Stoller 2001, page 1-49.
[17] Pantex contains 143 RCRA solid waste management units (SWMUs). Stoller, 2001, page 1-14.

scrap/salvage yard[18]. Because hazardous materials have been used at Pantex for more than 60 years, it is probably not possible to identify all areas where they have been handled, stored, spilled, buried, burned, or dumped - with or without the authorization of plant officials[19].

2.4 Contaminants in the Perched Aquifer

Contaminants in the perched aquifer come primarily from industrial wastewater discharged to ditches and playas. After being discharged, the contaminated water percolated downward through the vadose zone, to the water table of the perched aquifer.

Contaminants detected in the perched aquifer include high explosives (e.g., HMX, RDX, TNT), metals (e.g., boron, chromium), and solvents (e.g., TCE, PCE)[20]. Many of the contaminants are present in concentrations exceeding State and Federal drinking water standards[21].

Contaminants have been found in all four bodies of perched groundwater beneath Pantex (landfills, Playa 3, Pratt Playa, main)[22, 23]. DOE distinguishes two zones of contamination within the main body of perched groundwater: the southeast zone, and Zone 11. The southeast zone covers Playa 1 and the area around Zone 12, including contaminated groundwater that has migrated beyond the plant boundaries to the east and southeast. Zone 11 covers a relatively small area near Zone 11. This report focuses on the southeast zone. RDX is the most widespread contaminant in the perched aquifer. The extent of the RDX plume is shown in figure 2.3.

The upper vadose zone beneath the ditches and playas still contains large amounts of contaminated water. DOE estimates that contaminated water in the upper vadose zone will continue to drain to the perched aquifer for the next 150 to 200 years[24].

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[18] DOE 2002c, appendix A page 1; EPA 2000; page 2; Mason & Hanger Corporation 1993, pages 38 - 40.
[19] The lack of information regarding past releases of hazardous materials can result in groundwater contamination where it is not expected. An example is the area southeast of Playa 1, between monitor well PTX08-1002 and the plant boundary. In response to a TNRCC comment concerning lack of groundwater information in this area, DOE stated " *It is unlikely that groundwater contamination exists in the perched aquifer in this area due to a lack of potential historic or present sources or releases (i.e., Plant production facilities and buildings, drainage ditches, etc.)".* The groundwater in this area was subsequently found to be highly contaminated with RDX (>2000 µg/L). Stoller 2001, page 1-145 and figure 4-1.
[20] BWXT 2007a, page 3-17; and BWXT 2004a, figures 10.2.2-2 through 10.2.9-10.
[21] BWXT 2007a, page 3-8.
[22] BWXT 2004a, figures 10.2.2-2 through 10.2.9-10.
[23] A note regarding the domestic well in the Pratt Playa portion of the perched aquifer. DOE claims that it is completed "*where the perched groundwater is clean*" (DOE 2008a, page 10). However, low concentrations of high explosives (e.g., HMX, RDX, TNT) and solvents (e.g., TCE, PCE) have been detected in this portion of the aquifer (concentrations of explosives and solvents are generally less than 1 µg/L (DOE, 1998 – 2006; BWXT 2004a, chapter 10; and BWXT 2007e, chapter 4)). The latest available analyses show that low levels of contaminants (e.g., HMX, TCE) remain in the Pratt Playa portion of the perched aquifer (B&W Pantex 2008a, figures 19.2 and 19.15).
[24] BWXT 2007a, page 4-42.

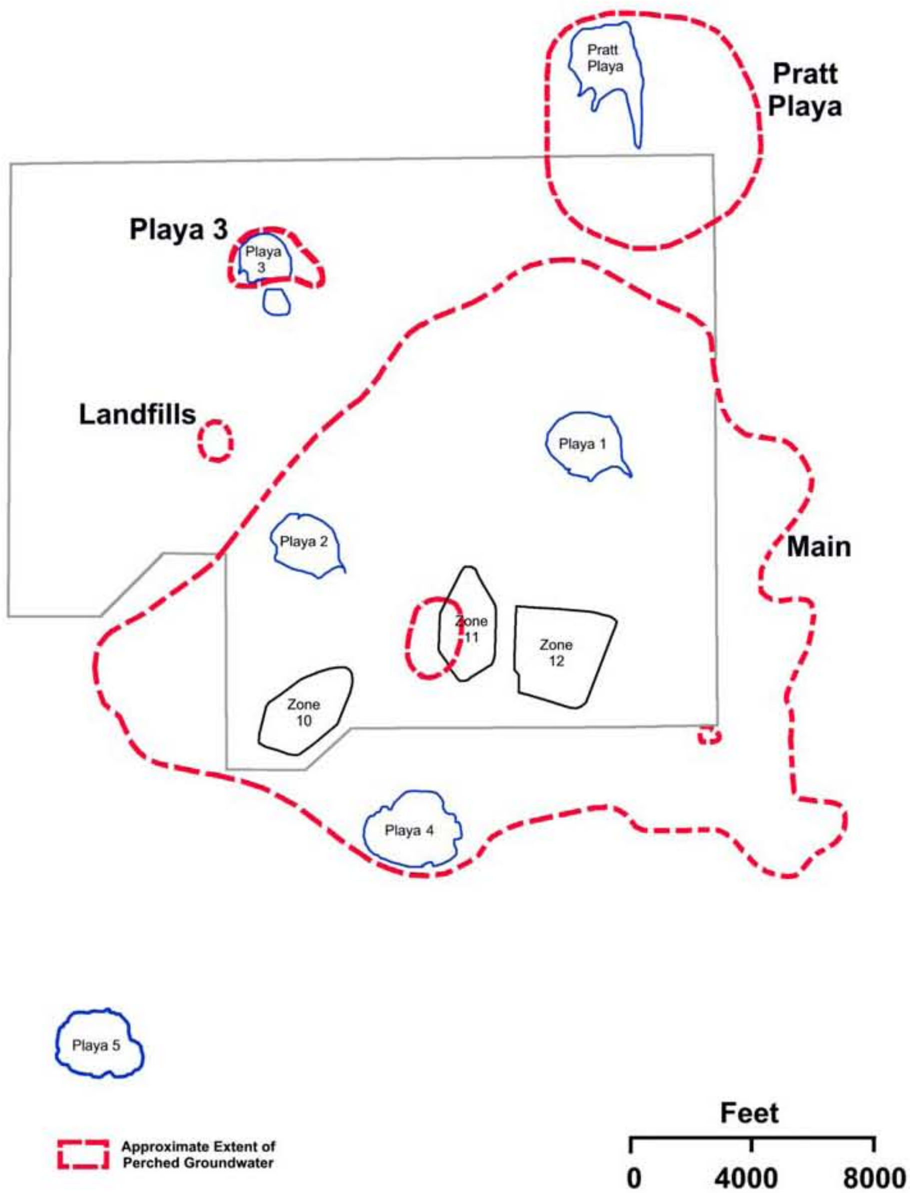

Figure 2.2
Bodies of Perched Groundwater

Adapted from BWXT 2007b, figure 4-2

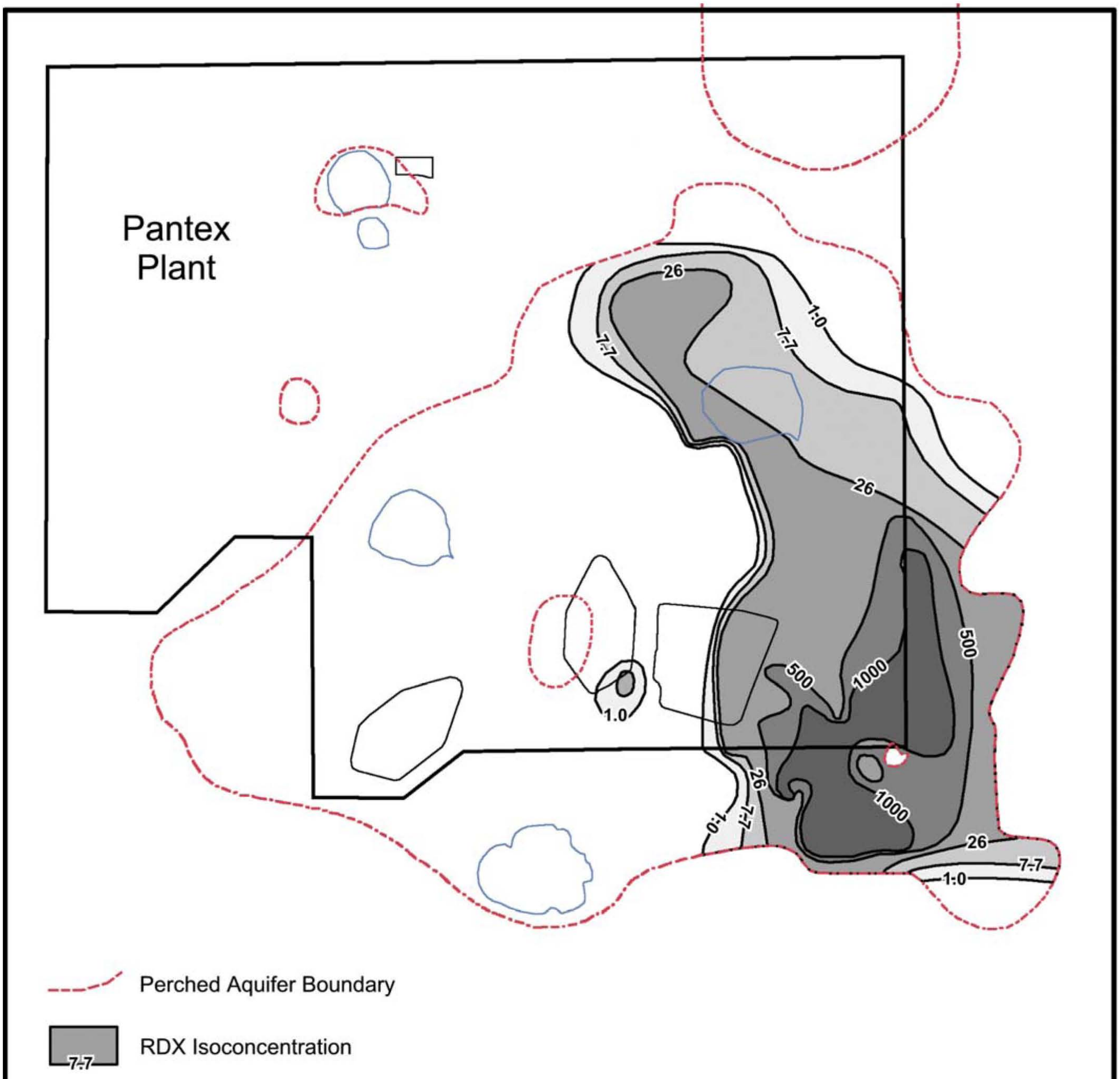

Figure 2.3
RDX in Perched Aquifer

Adapted from BWTX 2007a, figure 9-5

3.0 Efforts to Cleanup the Southeast Contaminant Plume

DOE is currently operating three cleanup systems to remove groundwater contaminants in the southeast plume. The first system (southeast pump and treat) began operating in September 1995[25] and has been modified several times since then.

Through March 2008, approximately 5700 pounds of high explosives (e.g., HMX, RDX, TNT) have been removed from the southeast plume (figure 3.1)[26].

DOE's cleanup goals are to[27]:

1. Prevent contact with contaminated groundwater.

2. Prevent expansion of the plume.

3. Reduce contaminant concentrations to health-based standards[28].

4. Prevent perched aquifer contaminants from reaching the Ogallala Aquifer in concentrations that would exceed health-based standards.

The groundwater cleanup levels that DOE will attempt to reach are listed in table 3.1. Much of the perched groundwater beneath Pantex will not be useable for the foreseeable future. DOE will impose institutional controls to restrict access to the perched aquifer[29].

The cleanup plans proposed by DOE will probably reduce the amount of contaminants flowing from the perched aquifer to the Ogallala Aquifer, but will not completely eliminate the flow[30]. Cleanup progress will be monitored through a long-term monitoring network. The long-term monitoring plan has not been completed[31].

[25] BWXT 2008a.
[26] DOE 2000 – 2006; B&W Pantex 2008a, page 16-1; and B&W Pantex 2008b.
[27] BWXT 2007a, pages 9-1 and 9-2. Cleanup goals are also known as remedial action objectives (RAOs).
[28] DOE 2008b, page 1-1. This is a change from DOE's original plan, which was to reduce contaminant concentrations to health-based standards only at points of exposure. Points of exposure are: 1) plant boundaries, and 2) areas where contaminants are likely to enter the vadose zone beneath the perched aquifer and drain to the Ogallala Aquifer (BWXT 2007a, page 9-2).
[29] BWXT 2007a, pages 9-9 and 9-41.
[30] BWXT 2007a, pages 9-26 and 9-27.
[31] DOE 2008b, page 1-2.

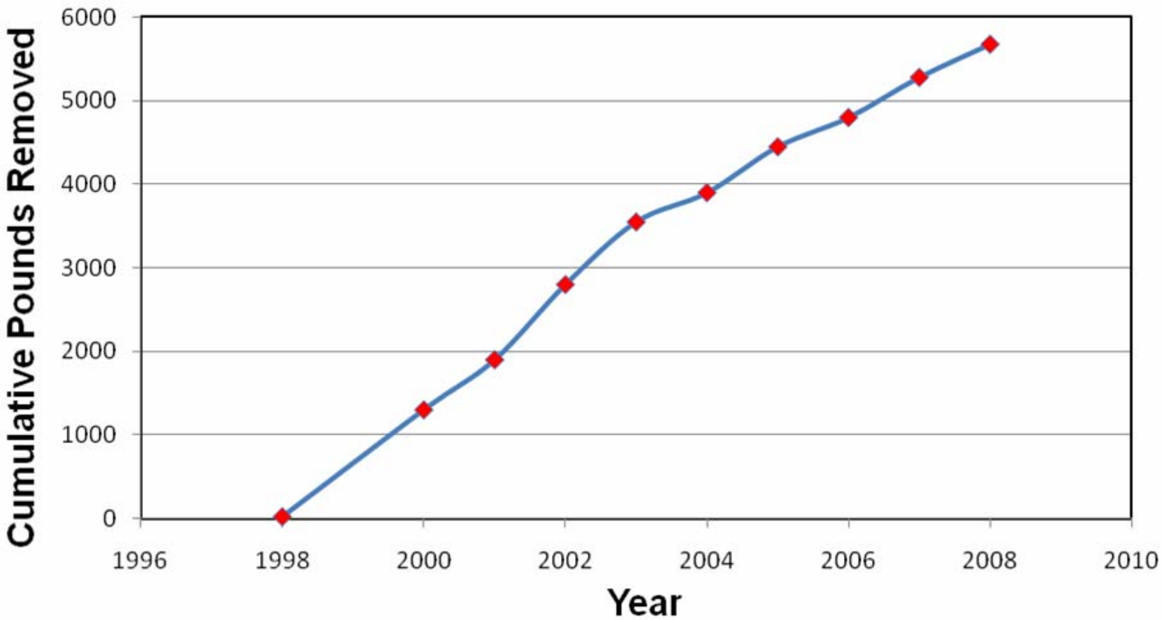

Figure B-1
Removal of High Explosives from the Southeast Contaminant Plume

The three cleanup systems for the southeast plume are (figure 3.2)[32]:

- The southeast pump and treat system: DOE will continue operating the pump and treat system in southeast portion of plant for 30 years. Fifteen additional extraction wells will be installed for a total of 67 extraction wells. The existing injection wells will be eliminated[33]. The extracted water will be treated and used for a beneficial purpose, such as irrigation[34].

- The Playa 1 pump and treat system: DOE is installing ten extraction wells near Playa 1[35]. The extracted water will be treated and used for a beneficial purpose, such as irrigation[36]. As of September 2008, this system was 90 percent complete[37].

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[32] BWXT 2007a, pages 9-20 through 9-22. This is DOE's preferred alternative for the southeast plume – alternative 5. DOE evaluated five cleanup alternatives (BWXT 2007a, pages 9-8 through 9-39).
[33] The injection wells are being eliminated because DOE believes that injection of treated water increases drainage to the Ogallala Aquifer (BWXT 2007a, page 9-22).
[34] BWXT 2007a, page 9-21.
[35] B&W Pantex 2008c, page 8.
[36] BWXT 2007a, page 9-21.
[37] B&W Pantex 2008c, page 8.

- The in-situ treatment system: DOE installed an in-situ treatment system to promote anaerobic biodegradation. A mixture of soybean oil, sodium lactate, sodium bicarbonate, and other materials is being injected into the contaminant plume. The purpose is to biodegrade explosives and volatile organics, and convert hexavalent chromium to trivalent chromium. Forty-two injection wells have been installed in two parallel rows[38].

Table 3.1
Cleanup Levels for Perched Groundwater[39]

Contaminant	Cleanup Level (µg/L)	Basis for Cleanup Level
High Explosives		
2-amino-4,6-dinitrotoluene	1.2	Texas[40]
4-amino-2,6-dinitrotoluene	1.2	Texas
1,3-dinitrobenzene	3.7	Texas
2,4-dinitrotoluene	1.0	PQL[41]
2,6-dinitrotoluene	1.0	PQL
HMX	360	Texas
RDX	2.0[42]	Texas
1,3,5-trinitrobenzene	220	Texas
TNT	3.6	Texas
Volatile Organics		
1,2-dichloroethane	5.0	MCL[43]
1,4-dioxane	7.7	Texas
Chloroform	80	MCL[44]
TCE	5.0	MCL
PCE	5.0	MCL
Metals		
Boron	7300	Texas
Chromium (hexavalent)	100	MCL
Chromium (total)	100	MCL
Other		
Perchlorate	26	Texas

[38] BWXT 2008a.
[39] BWXT 2007a, page 9-3.
[40] Texas Commission on Environmental Quality standard No. 2 for residential use.
[41] Practical Quantitation Limit, generally five times higher than the analytical detection limit (DOE 2002a, page 28).
[42] The cleanup level was reduced from 7.7 µg/L (per CMS/FS (BWXT 2007a)) to 2.0 µg/L. The lower level is the EPA Lifetime Health Advisory level for RDX (DOE 2008b, page 2-143).
[43] Maximum Contaminant Level, the US EPA drinking water standard.
[44] The cleanup level was reduced from 370 µg/L (per CMS/FS (BWXT 2007a)) to 80 µg/L. The lower level is the MCL (EPA 2006).

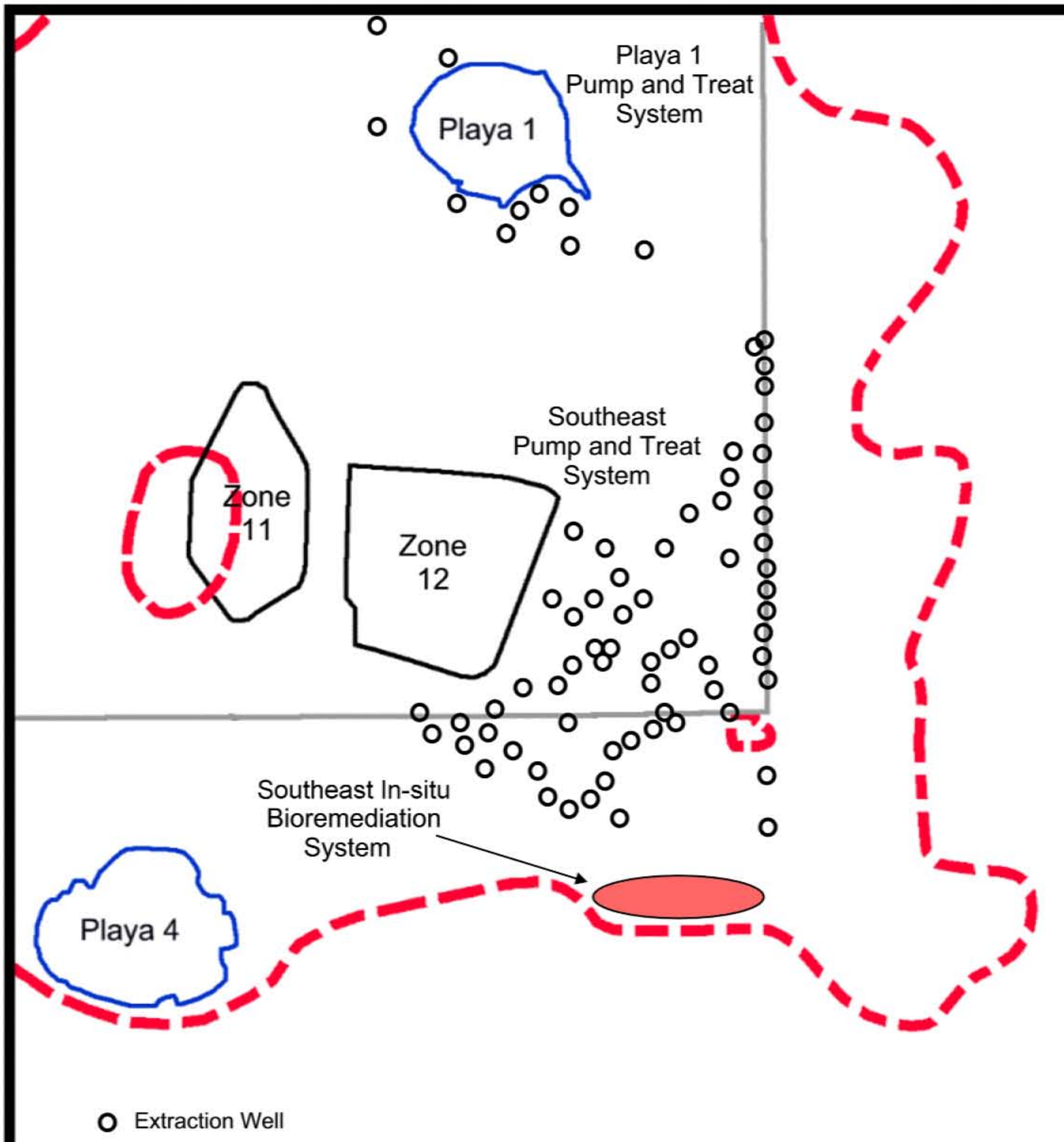


Figure 3.2
Perched Groundwater Treatment Systems
Southeast Plume

Adapted from BWXT2007a, figures 9-13 and 9-15; and B&W 2008c, page 7

4.0 Effectiveness of the Cleanup System

The graphs at the end of this section show the progress that has been made in cleaning up RDX at individual wells[45]. The first 14 pairs of graphs depict RDX histories for perched aquifer wells within 1000 feet of an extraction well[46]. Presumably, these 14 wells are more likely to be affected by the cleanup system than are wells that are farther from the extraction wells. These wells are listed in table 4-1. The remaining 18 pairs of graphs depict RDX histories for wells completed throughout the main body of perched groundwater. These wells are more than 1000 feet from any extraction well. The changes in RDX concentrations at these 18 wells are probably not due to the operation of the cleanup system. Well locations are shown in figure 4-1.

Two versions of each graph are presented. The first is with an arithmetic concentration scale (vertical scale). The arithmetic scales are not uniform. Instead, they are adjusted based on concentrations. This best displays the variation in RDX concentrations with time. The second version is with a logarithmic concentration scale. Each logarithmic concentration scale is the same (0.1 µg/L – 10,000 µg/L). This makes it easier to compare concentrations between wells.

Table 4-1
Wells within 1000 Feet of Extraction Wells

PTX06-1003	PTX06-1031	PTX06-1052
PTX06-1005	PTX06-1038	PTX06-1088
PTX06-1014	PTX06-1039A	PTX08-1008
PTX06-1015	PTX06-1041	PTX08-1009
PTX06-1030	PTX06-1042	

The wells listed in table 4-1 can be placed into three groups:

1. Two wells where RDX concentrations have always been less than the cleanup level of 2.0 µg/L: wells PTX06-1052 and PTX08-1008.

2. Seven wells where RDX concentrations have declined[47]: wells PTX06-1003, PTX06-1005, PTX06-1038, PTX06-1039A, PTX06-1041, PTX06-1042, and PTX06-1088.

   The wells with decreasing concentrations are in the northern and central portions of the pump and treat system. The decreases in RDX concentrations may be due to 1) the removal of RDX by the extraction system, 2) dilution caused by the

[45] Data sources: DOE, 1998 – 2006; BWXT 2007d, chapter 4; TCEQ 2008a; and B&W Pantex, 2008a, chapter 4. Where more than one value is reported in a quarter, the values are averaged.
[46] BWXT 2007b, page 2-11.
[47] Decline was defined as an RDX history trend-line (linear) with a negative slope. To calculate the slope, the data were graphed with time expressed in days since the first sample was collected. For example, the equation for the PTX06-1041 trend-line was: RDX = - 0.11 day + 1211, r^2 = 0.20.

injection of treated water[48], or 3) migration of less-contaminated water from up-gradient portions of the plume.

RDX concentrations have decreased to levels below the 2.0 µg/L cleanup level in one well: PTX06-1003. RDX concentrations in the other six wells remain well above the cleanup level. They range from 304 µg/L in PTX06-1088 to 1080 µg/L in PTX06-1041.

3. Five wells where RDX concentrations have increased[49]: wells PTX06-1014, PTX06-1015, PTX06-1030, PTX06-1031, and PTX08-1009.

   The wells with increasing concentrations are in the southern portion of the pump and treat system. The increases in RDX concentrations may be due to 1) migration of RDX from up-gradient portions of the plume, or 2) drainage of RDX from the vadose zone.

   The RDX concentrations in these wells remain well above the 2.0 µg/L cleanup level. They range from 30 µg/L in PTX08-1009 to 1730 µg/L in PTX06-1030.

4.1 Conclusions

Overall, the treatment systems have been only marginally effective[50]. Although approximately 5700 pounds of high explosives have been removed since 1995, this is a relatively small portion of the 95,000 pounds of RDX that DOE estimates is present in the perched aquifer and vadose zone.

RDX concentrations have been reduced to concentrations below the cleanup level in only one of the wells that are within 1000 feet of an extraction well: PTX06-1003. The cause of this reduction may be the influx of treated water from a nearby injection well. In many wells, RDX concentrations remain well above the 2.0 µg/L cleanup level, and there is no indication that RDX concentrations will be reduced to the cleanup level in the foreseeable future.

[48] Wells PTX06-1003 and PTX06-1005 are adjacent to pump and treat system injection wells (BWXT 2007b, page 2-11).
[49] Increase was defined as an RDX history trend-line (linear) with a positive slope. To calculate the slope, the data were graphed with time expressed in days since the first sample was collected. For example, the equation for the PTX06-1031 trend-line was: RDX = 0.31 day – 235, $r^2 = 0.88$.
[50] It should be noted that the Playa 1 pump and treat system and the in-situ bioremediation system were not fully operating at the beginning of 2008. Thus, the available water quality analyses (through 2007) do not show the full effects that these systems may have on contaminant concentrations.

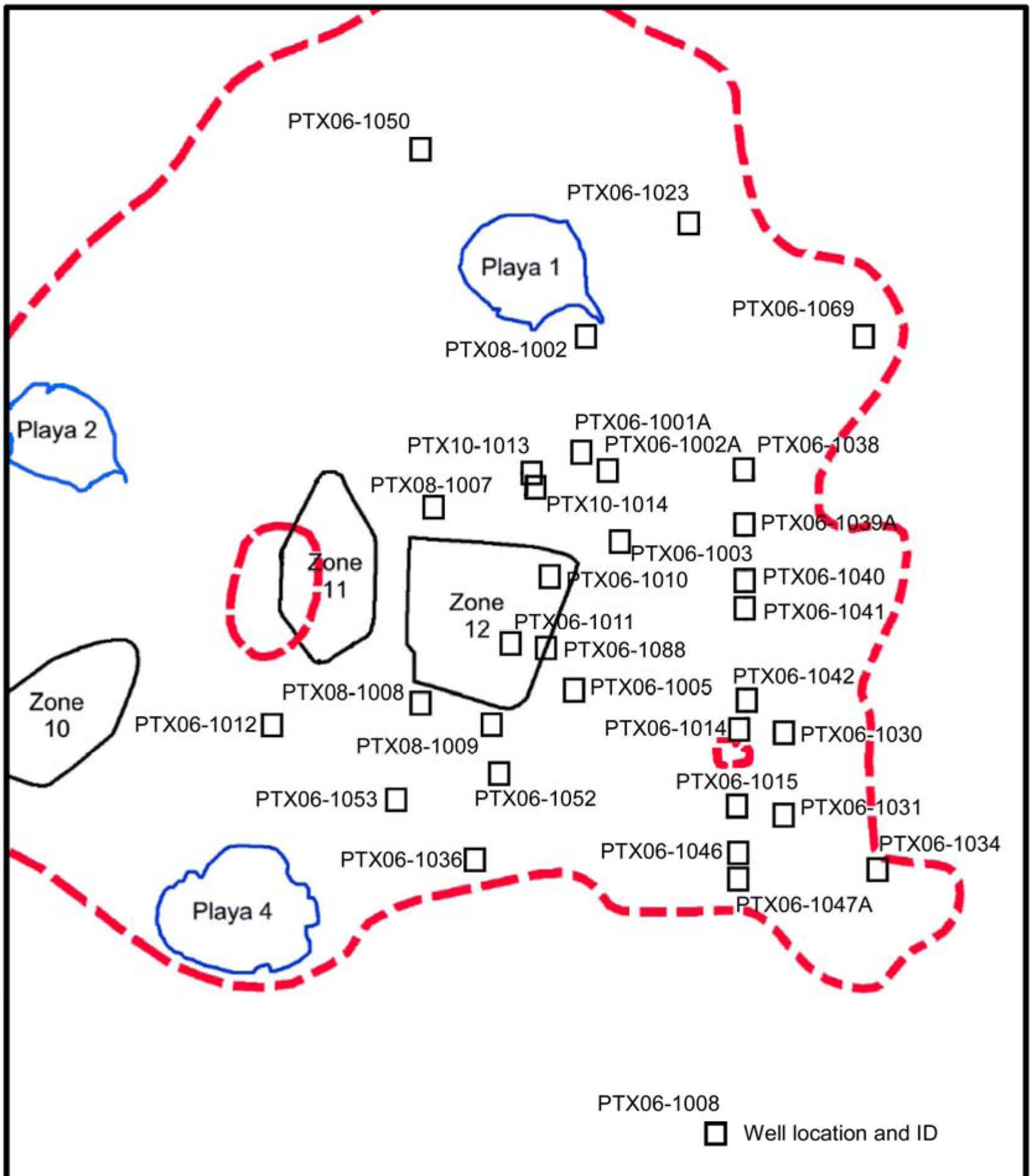
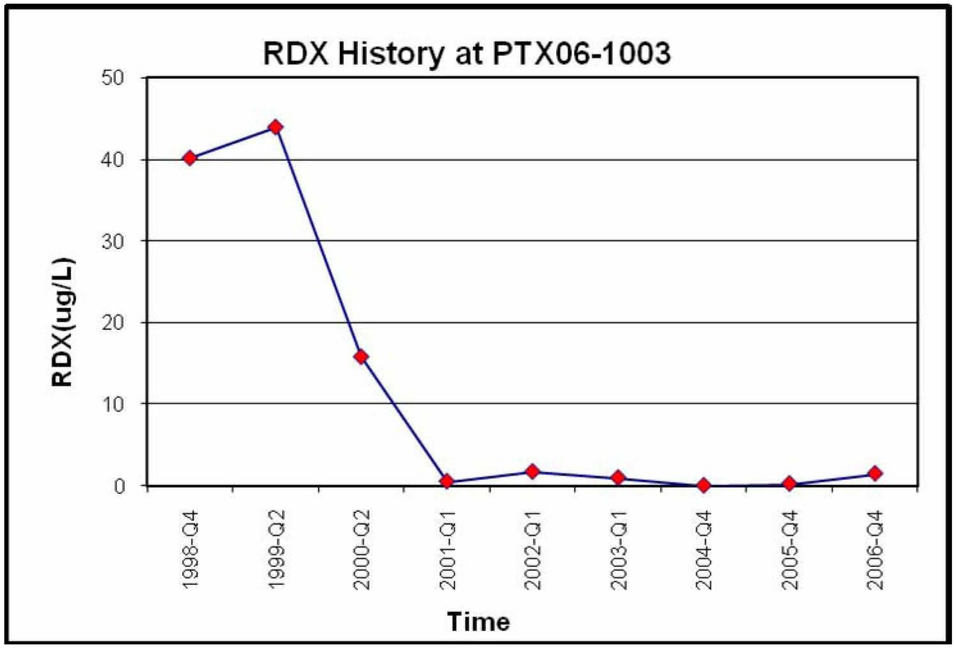
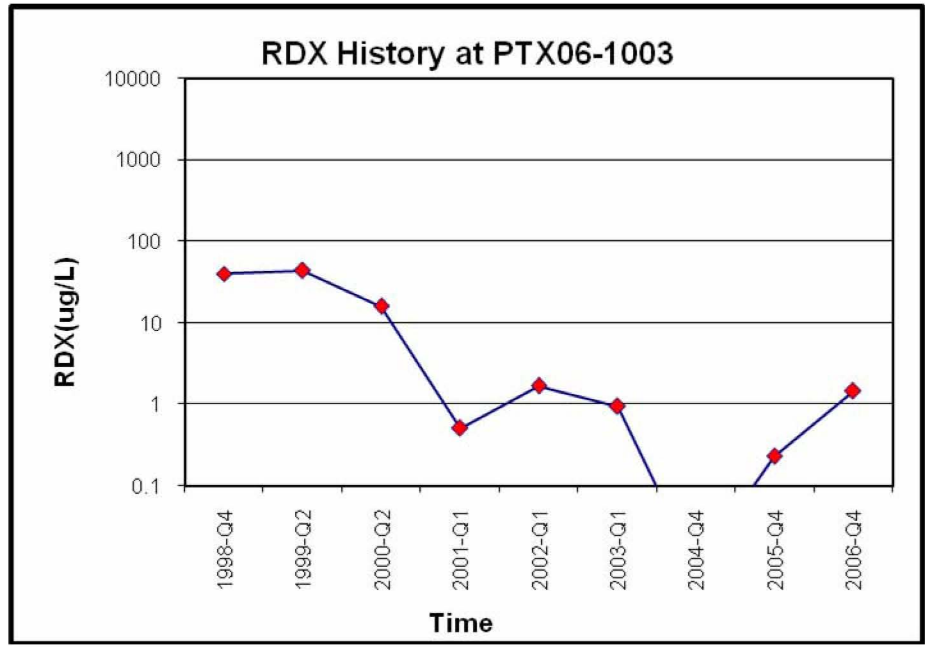
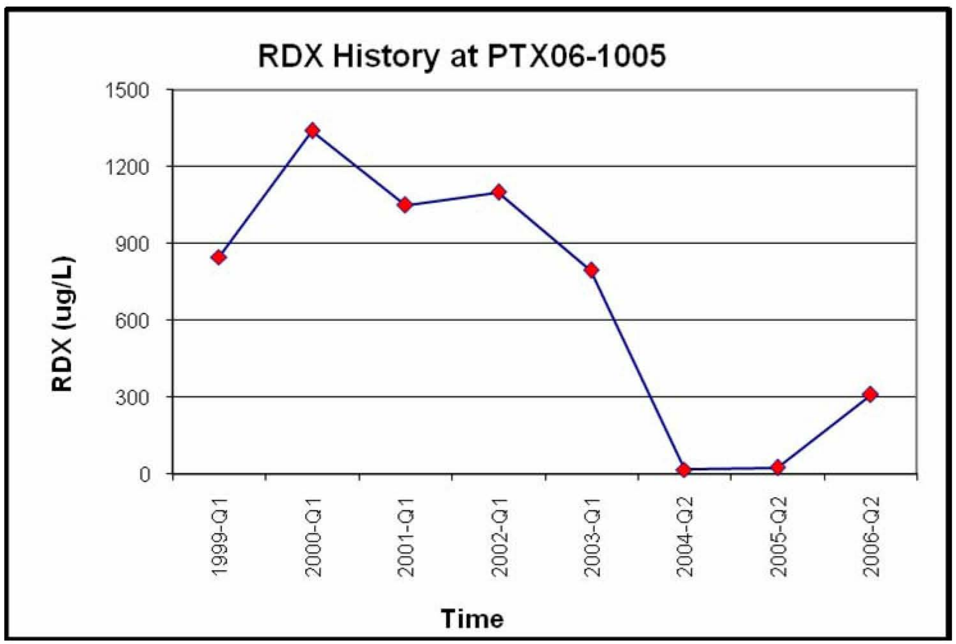


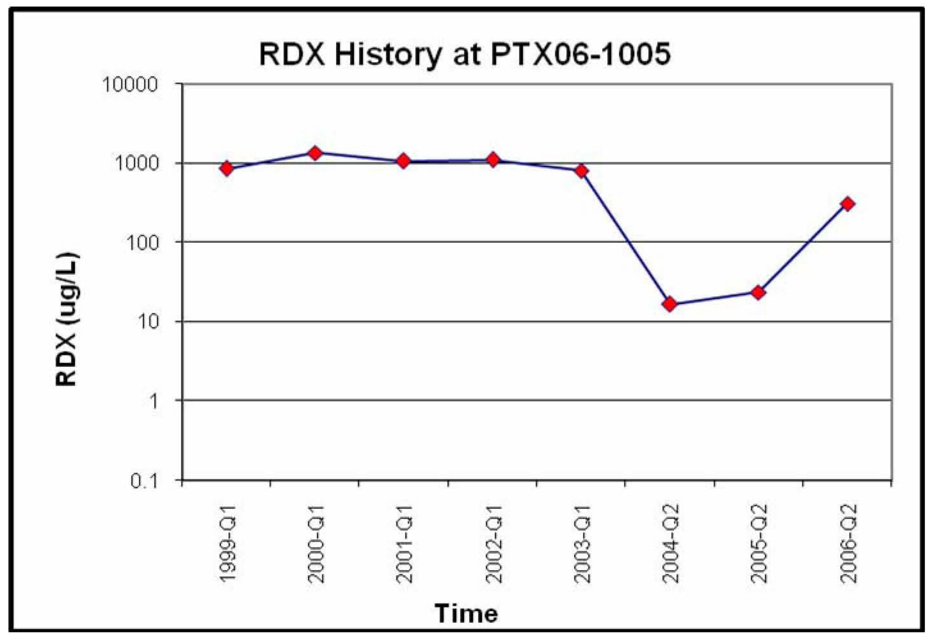
Figure 4.1
Approximate Locations of Wells for Which RDX Histories are Provided

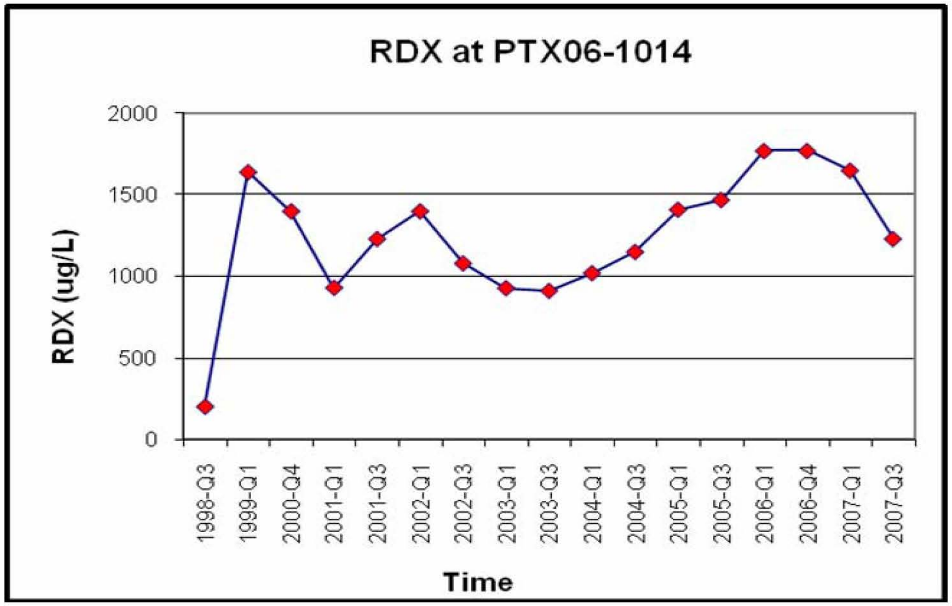
RDX histories for perched aquifer wells within 1000 feet of an extraction well in the southeast pump and treat system


RDX History at PTX06-1003
50
40
30
20
10
0
RDX(ug/L)
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1
2004-Q4
2005-Q4
2006-Q4
Time


RDX History at PTX06-1003
10000
1000
100
10
1
0.1
RDX(ug/L)
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1
2004-Q4
2005-Q4
2006-Q4
Time


RDX History at PTX06-1005
1500
1200
900
600
300
0
RDX (ug/L)
1999-Q1
2000-Q1
2001-Q1
2002-Q1
2003-Q1
2004-Q2
2005-Q2
2006-Q2
Time


RDX History at PTX06-1005
10000
1000
100
10
1
0.1
RDX (ug/L)
1999-Q1
2000-Q1
2001-Q1
2002-Q1
2003-Q1
2004-Q2
2005-Q2
2006-Q2
Time


RDX at PTX06-1014
RDX (ug/L)
2000
1500
1000
500
0
1998-Q3
1999-Q1
2000-Q4
2001-Q1
2001-Q3
2002-Q1
2002-Q3
2003-Q1
2003-Q3
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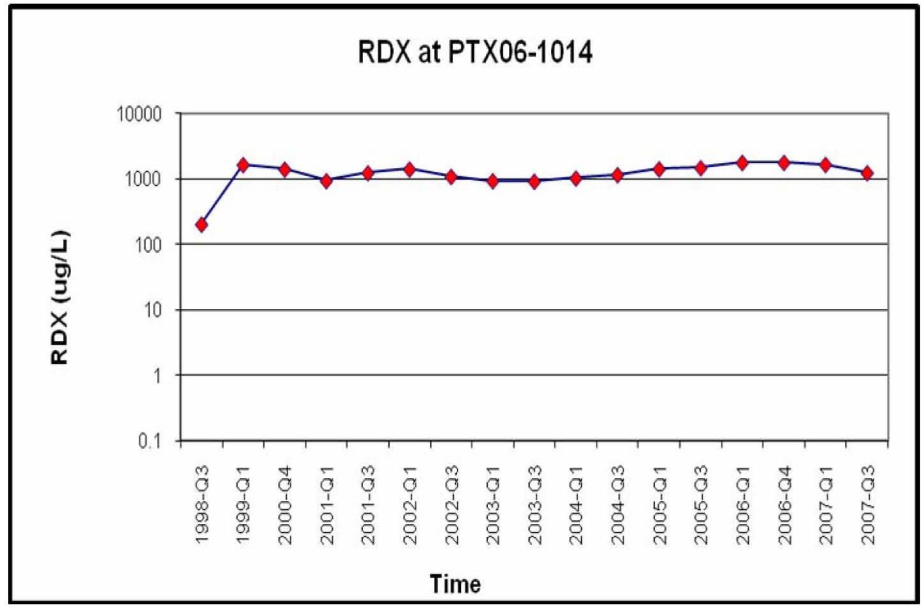
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q4
2007-Q1
2007-Q3
Time


RDX at PTX06-1014
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q1
2000-Q4
2001-Q1
2001-Q3
2002-Q1
2002-Q3
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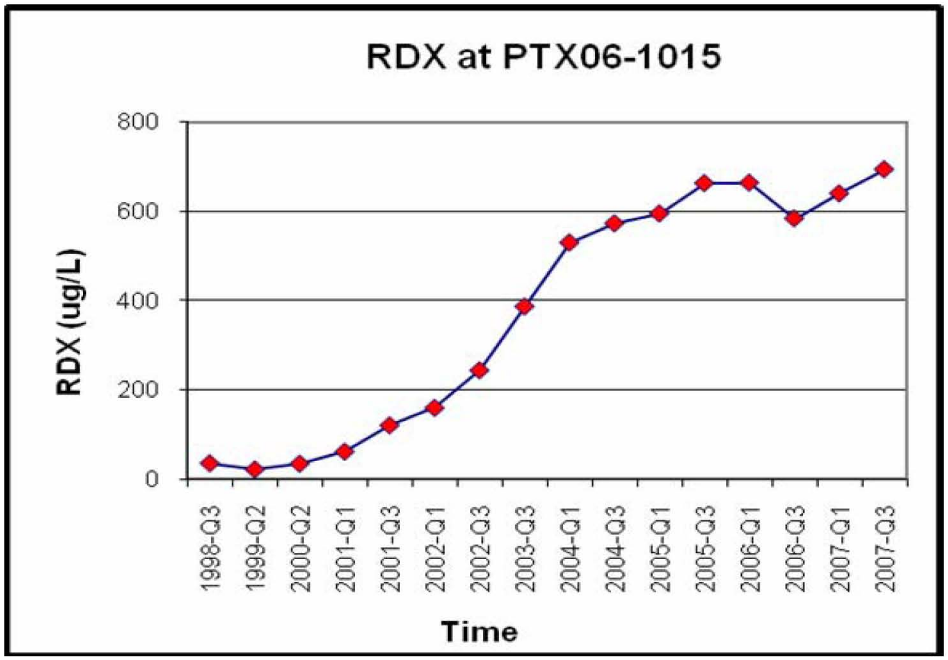
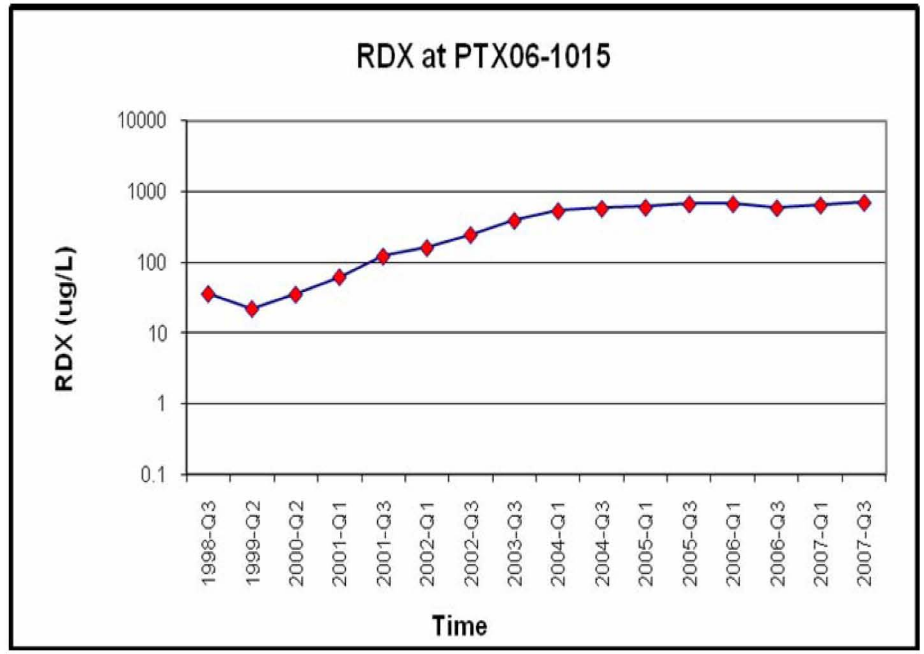
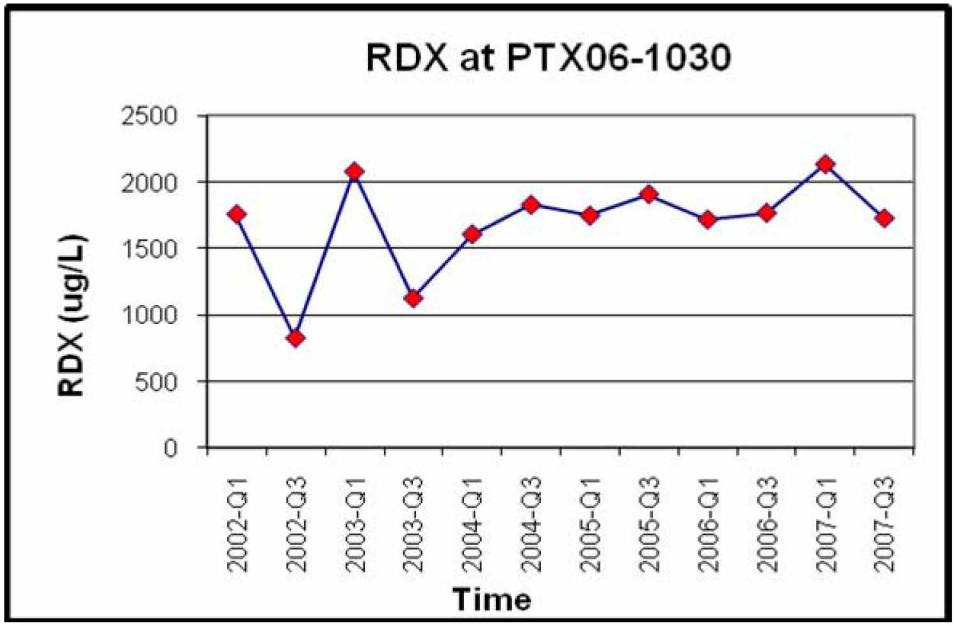
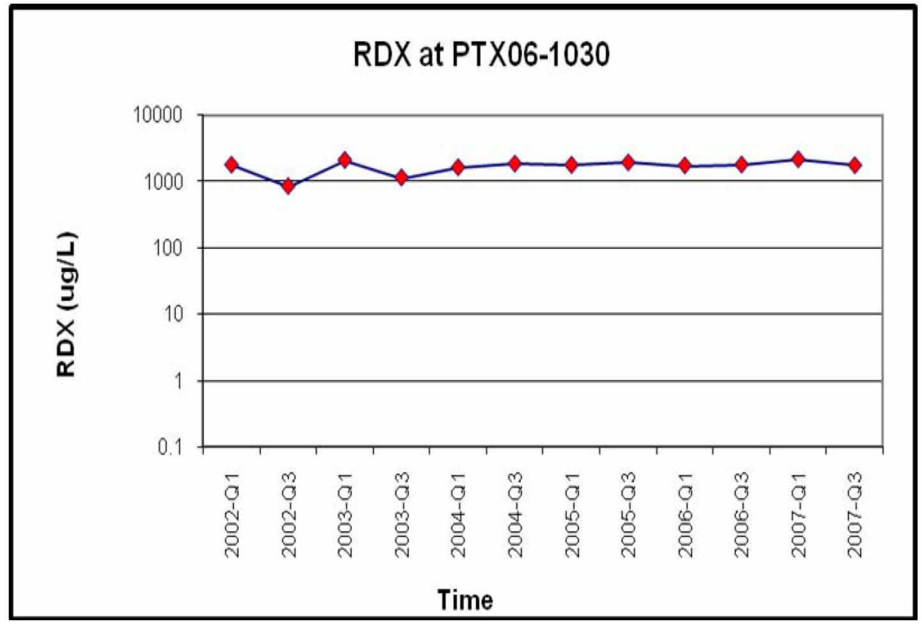
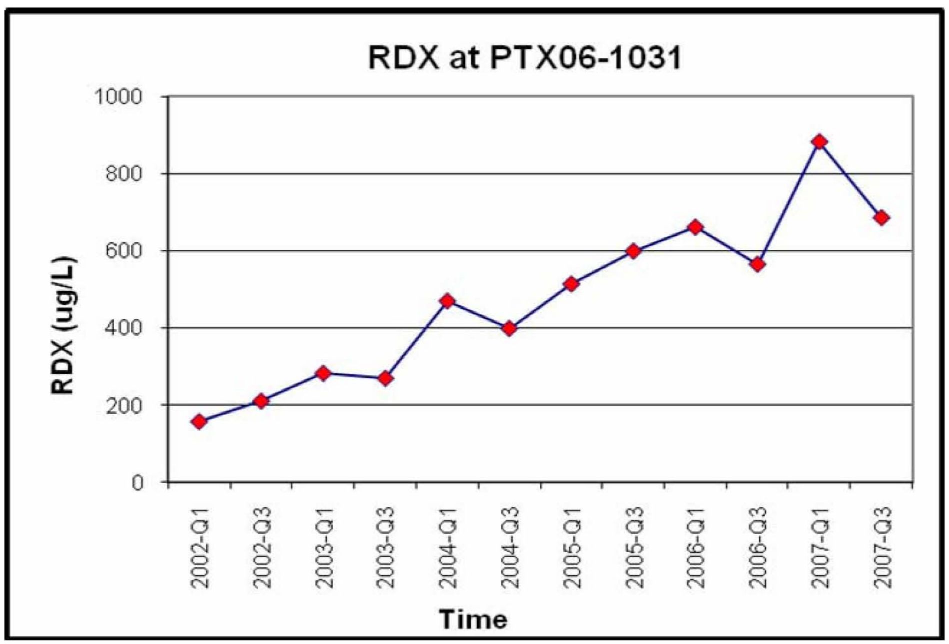
2007-Q1
2007-Q3
Time

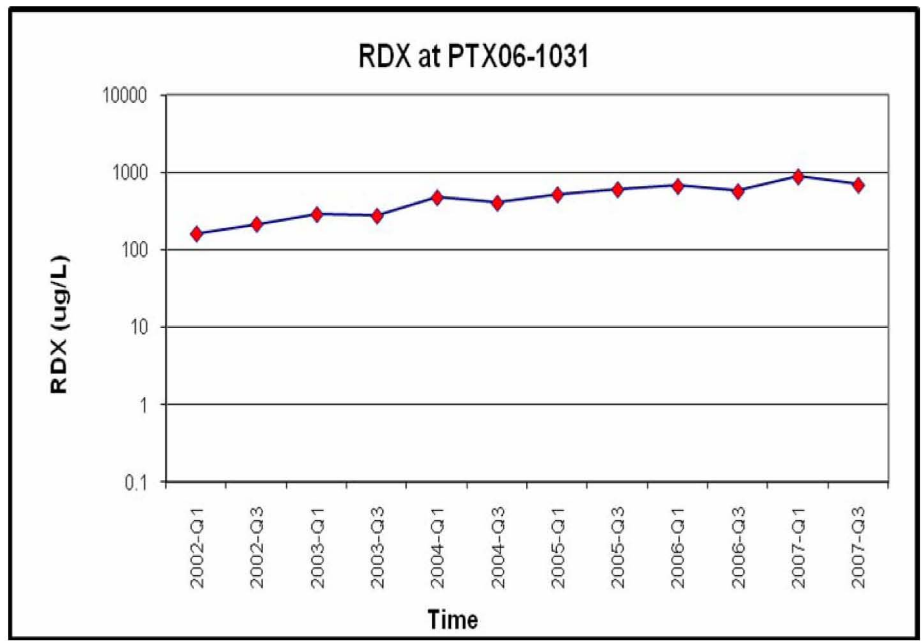

RDX at PTX06-1015
RDX (ug/L)
800
600
400
200
0
1998-Q3
1999-Q2
2000-Q2
2001-Q1
2001-Q3
2002-Q1
2002-Q3
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

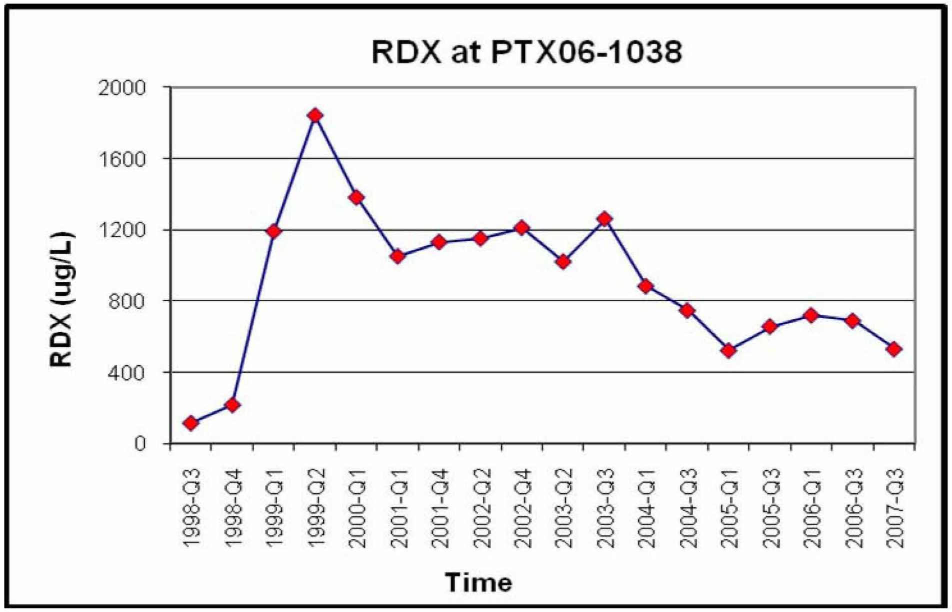

RDX at PTX06-1015
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q2
2000-Q2
2001-Q1
2001-Q3
2002-Q1
2002-Q3
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

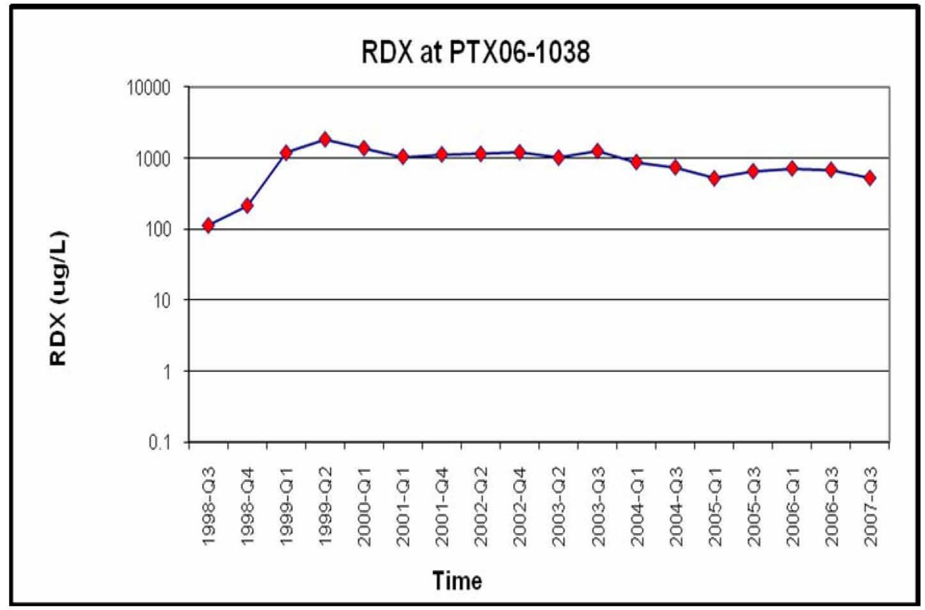

RDX at PTX06-1030
2500
2000
1500
1000
500
0
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

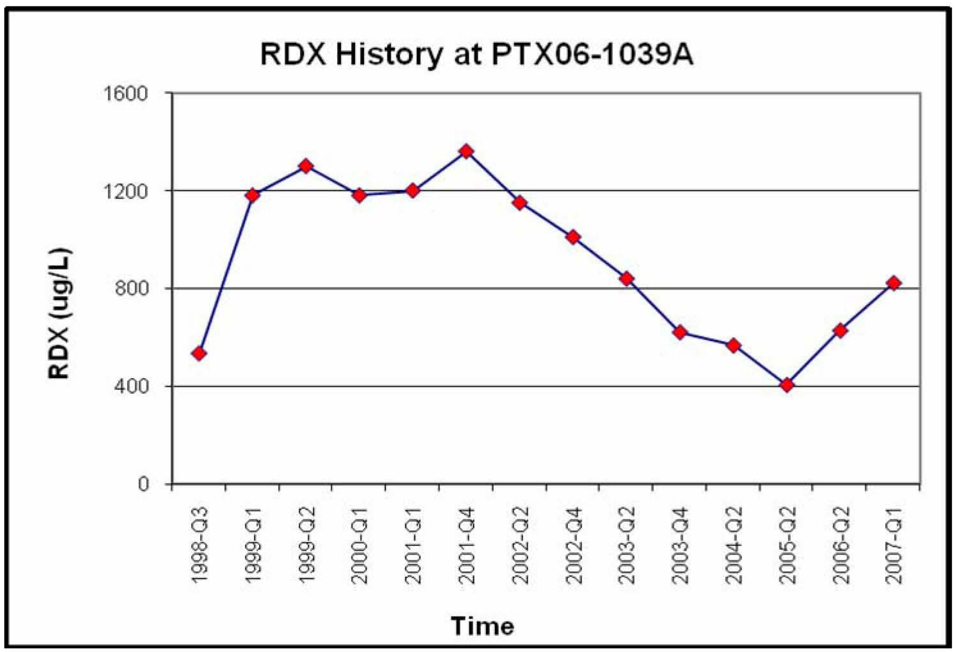

RDX at PTX06-1030
10000
1000
100
10
1
0.1
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

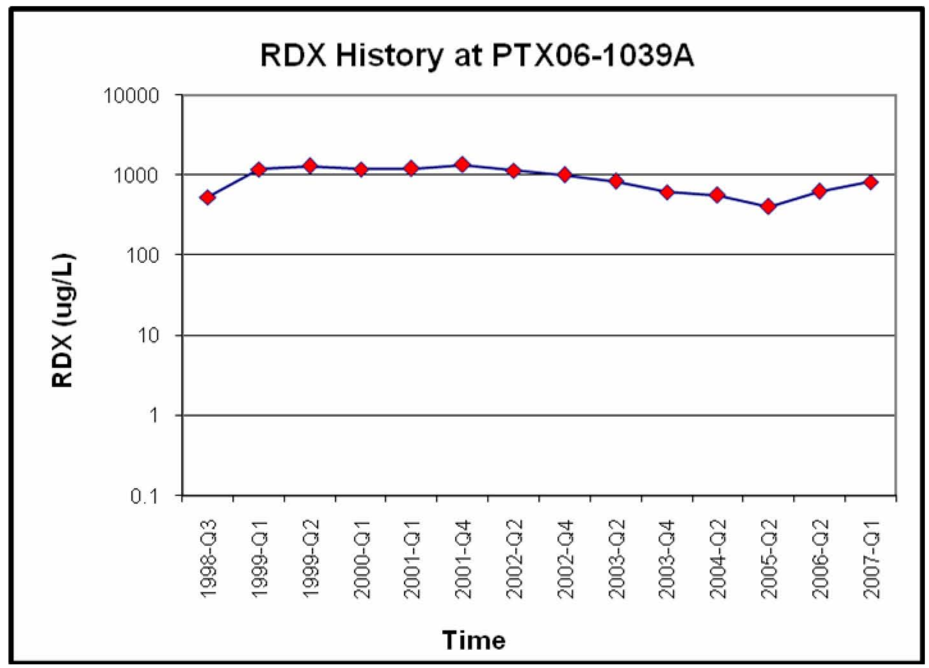

RDX at PTX06-1031
1000
800
600
400
200
0
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

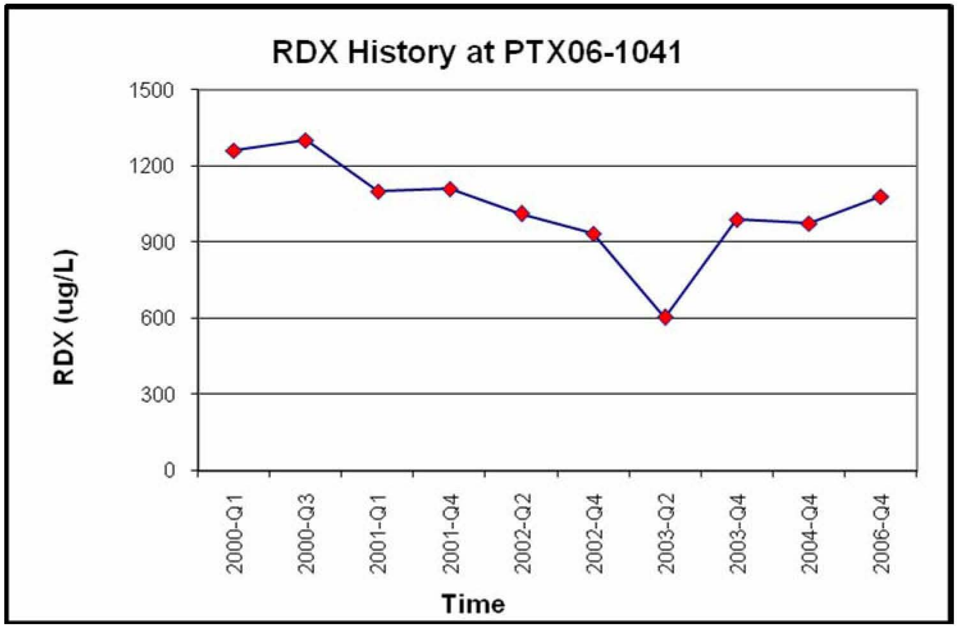

RDX at PTX06-1031
10000
1000
100
10
1
0.1
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

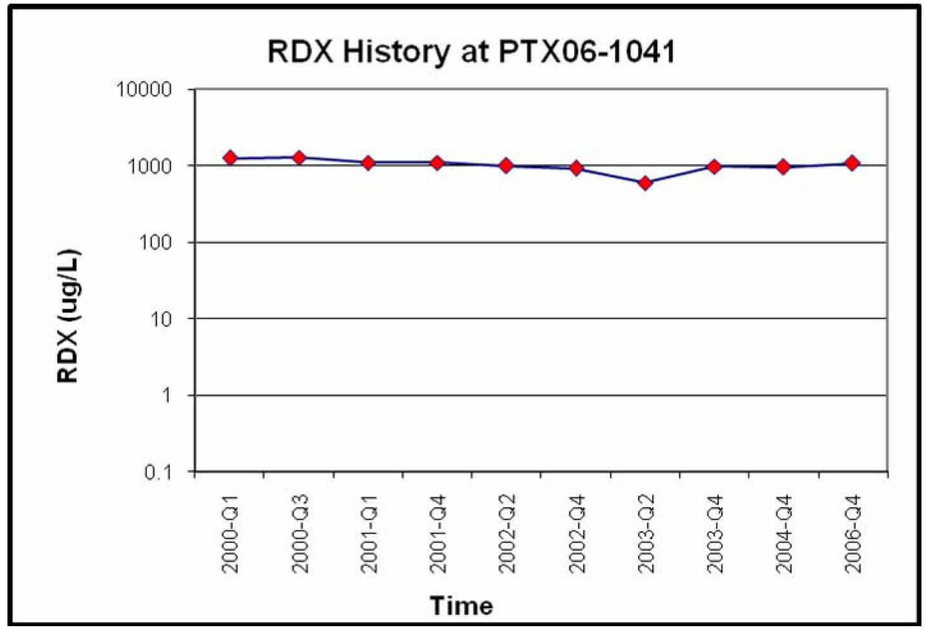

RDX at PTX06-1038
RDX (ug/L)
2000
1600
1200
800
400
0
1998-Q3
1998-Q4
1999-Q1
1999-Q2
2000-Q1
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q3
Time

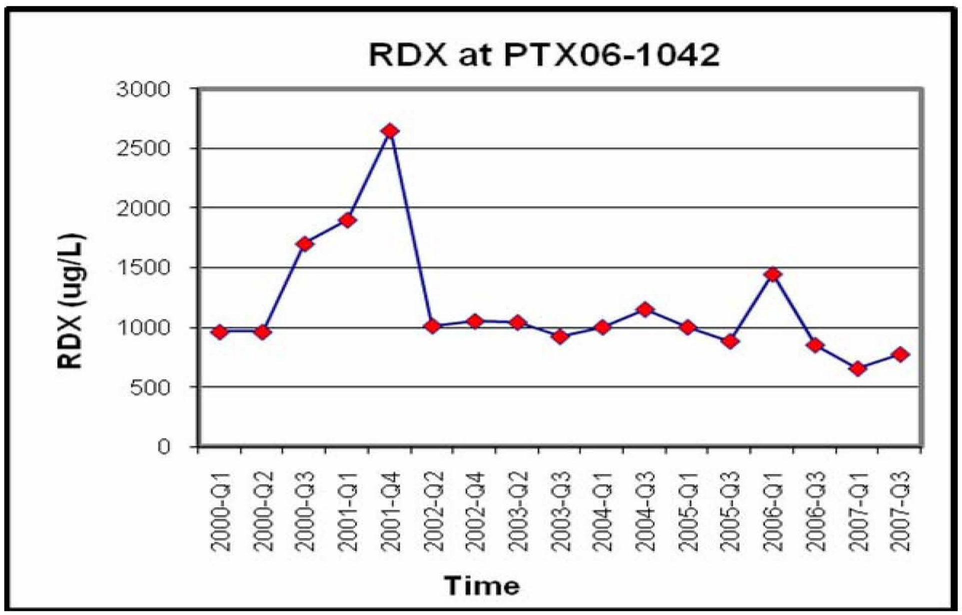

RDX at PTX06-1038
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1998-Q4
1999-Q1
1999-Q2
2000-Q1
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q3
Time

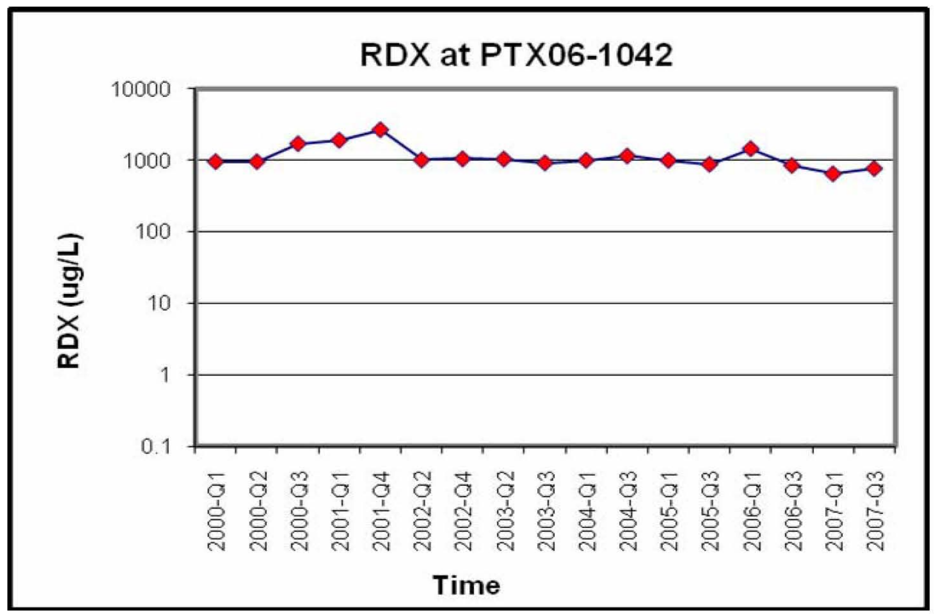

RDX History at PTX06-1039A
RDX (ug/L)
1600
1200
800
400
0
1998-Q3
1999-Q1
1999-Q2
2000-Q1
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q2
2005-Q2
2006-Q2
2007-Q1
Time

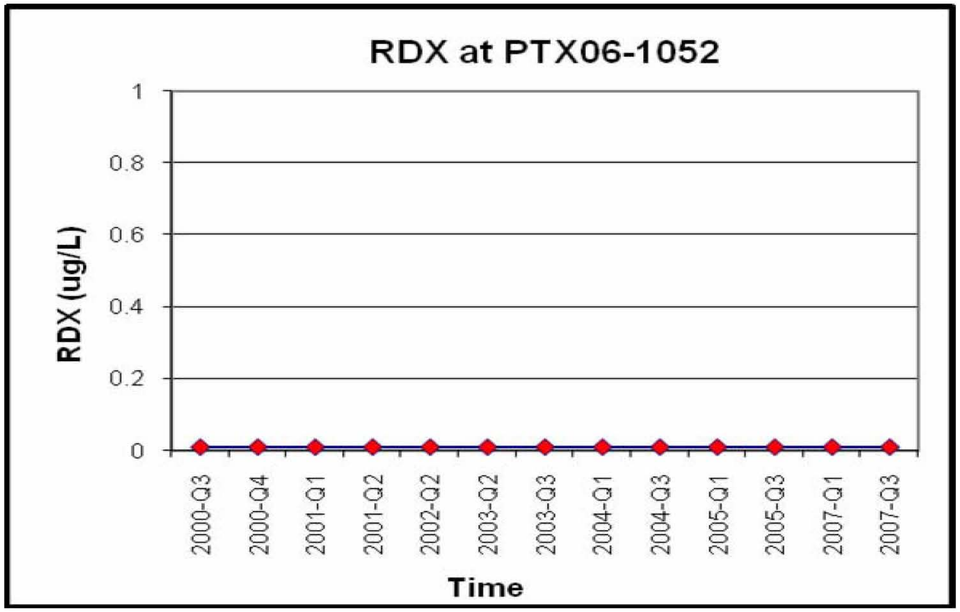

RDX History at PTX06-1039A
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q1
1999-Q2
2000-Q1
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q2
2005-Q2
2006-Q2
2007-Q1
Time

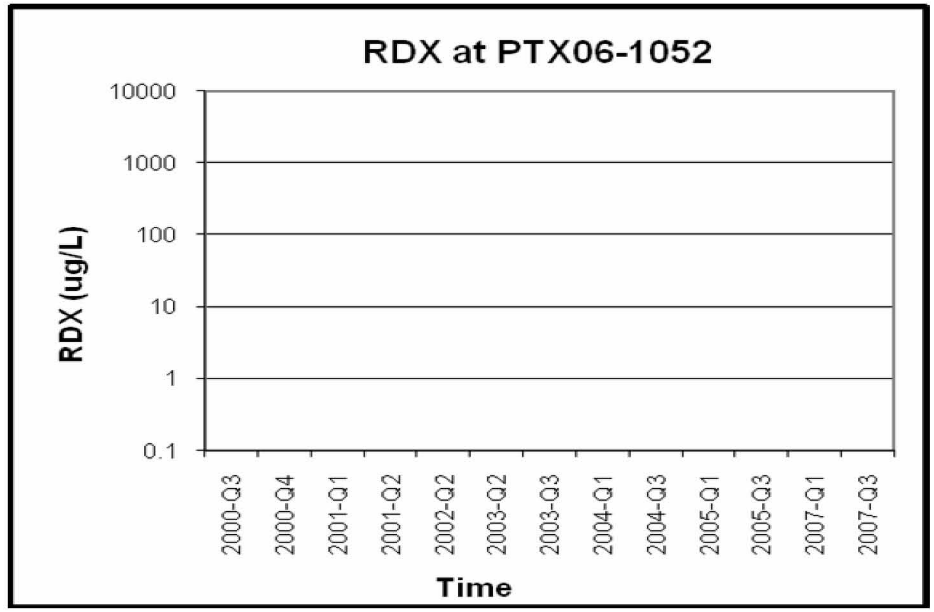

RDX History at PTX06-1041
RDX (ug/L)
1500
1200
900
600
300
0
2000-Q1
2000-Q3
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q4
2006-Q4
Time

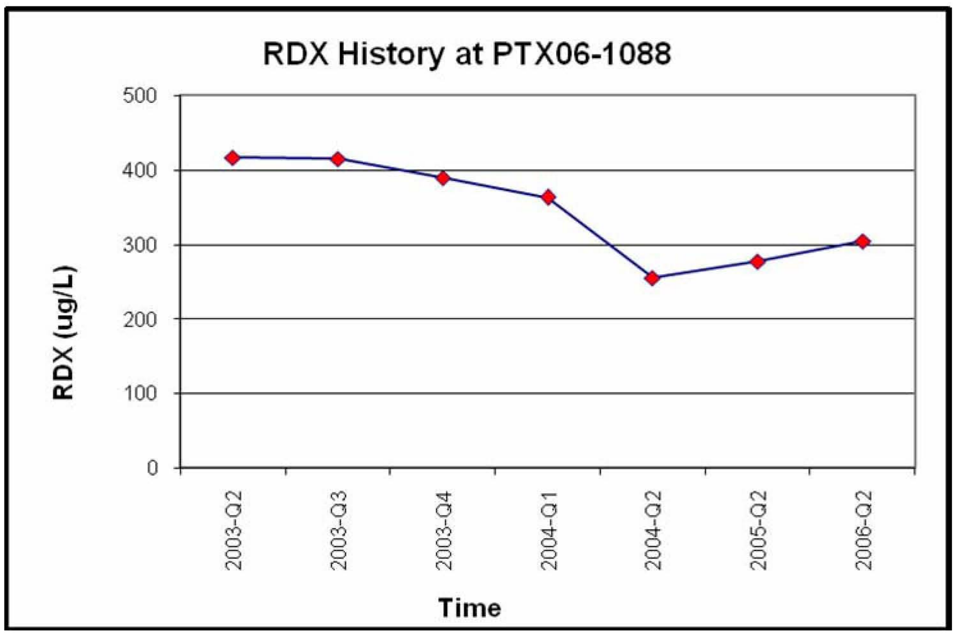

RDX History at PTX06-1041
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q1
2000-Q3
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q4
2006-Q4
Time

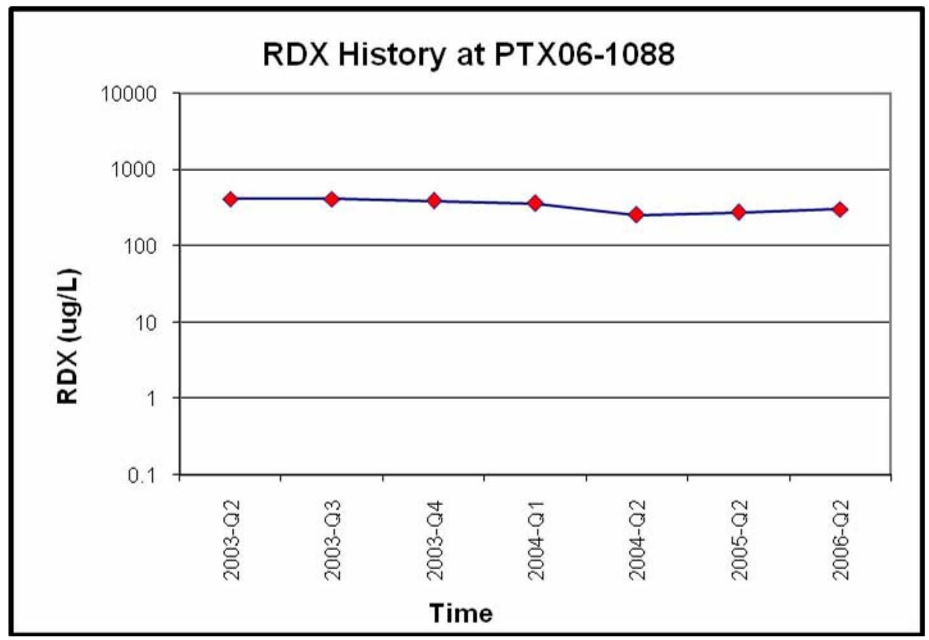

RDX at PTX06-1042
RDX (ug/L)
3000
2500
2000
1500
1000
500
0
2000-Q1
2000-Q2
2000-Q3
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

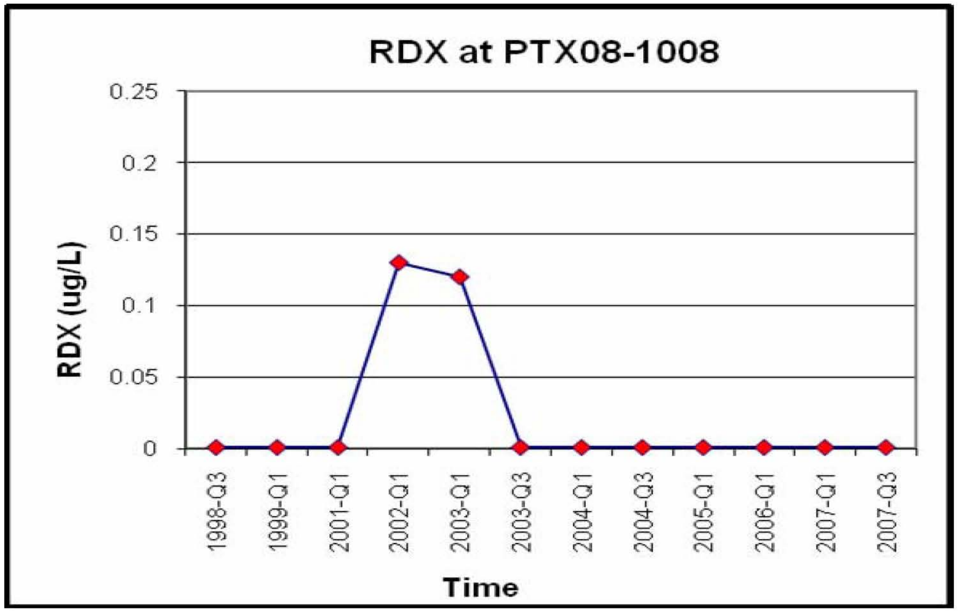

RDX at PTX06-1042
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q1
2000-Q2
2000-Q3
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

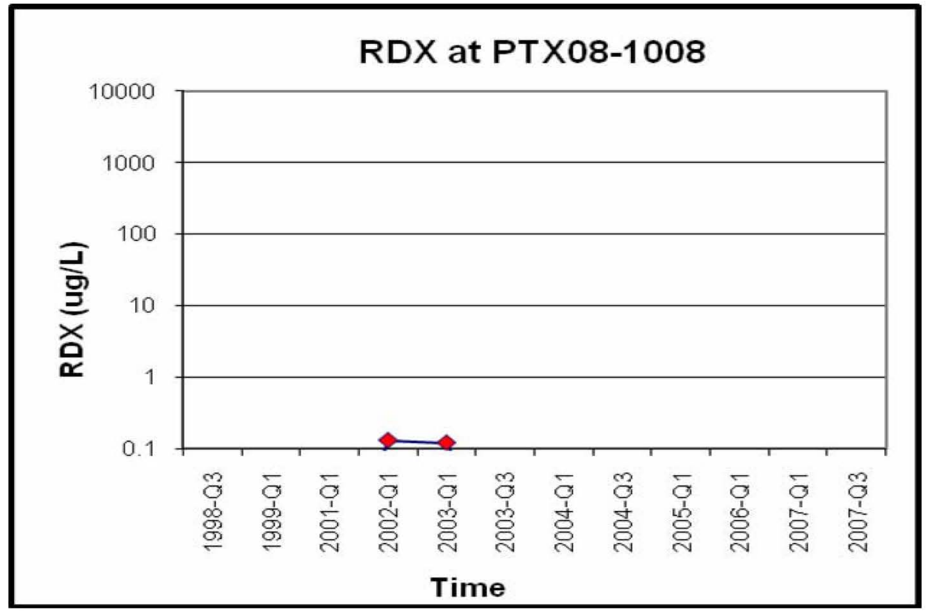

RDX at PTX06-1052
RDX (ug/L)
1
0.8
0.6
0.4
0.2
0
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2002-Q2
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q1
2007-Q3
Time

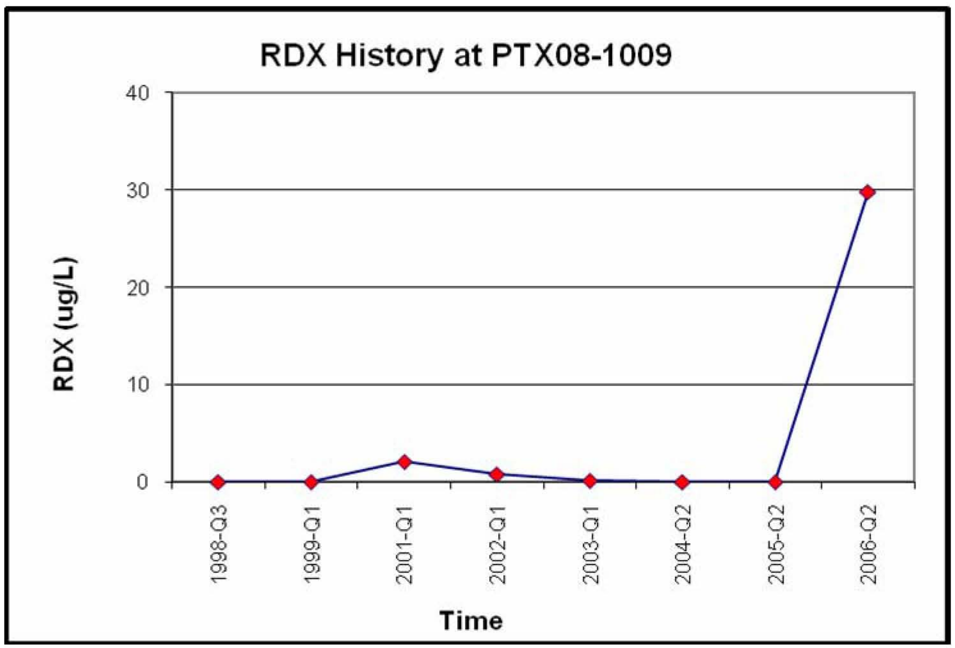

RDX at PTX06-1052
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2002-Q2
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q1
2007-Q3
Time

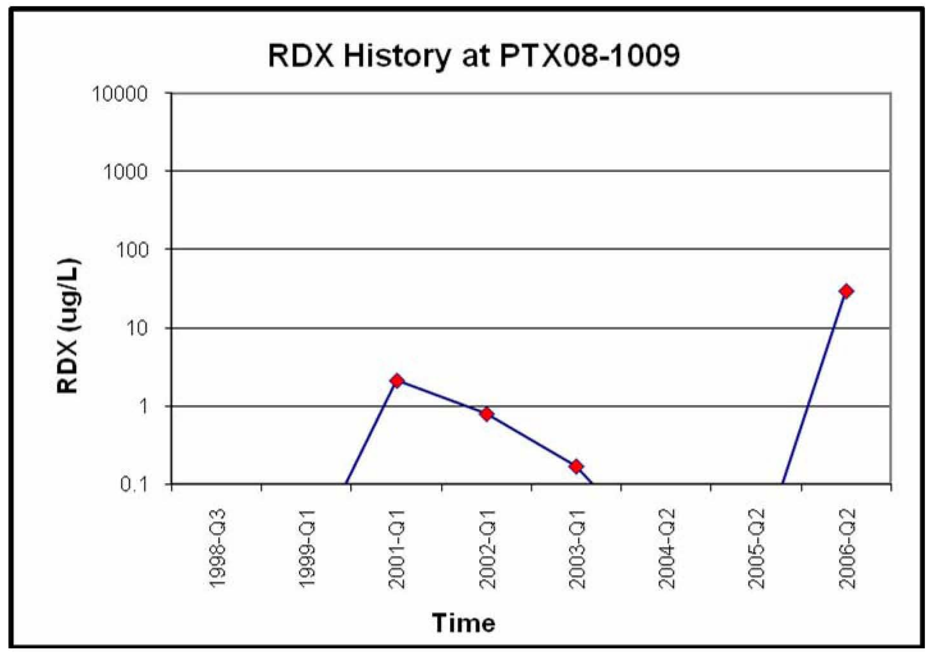

RDX History at PTX06-1088
RDX (ug/L)
500
400
300
200
100
0
2003-Q2
2003-Q3
2003-Q4
2004-Q1
2004-Q2
2005-Q2
2006-Q2
Time


RDX History at PTX06-1088
RDX (ug/L)
10000
1000
100
10
1
0.1
2003-Q2
2003-Q3
2003-Q4
2004-Q1
2004-Q2
2005-Q2
2006-Q2
Time

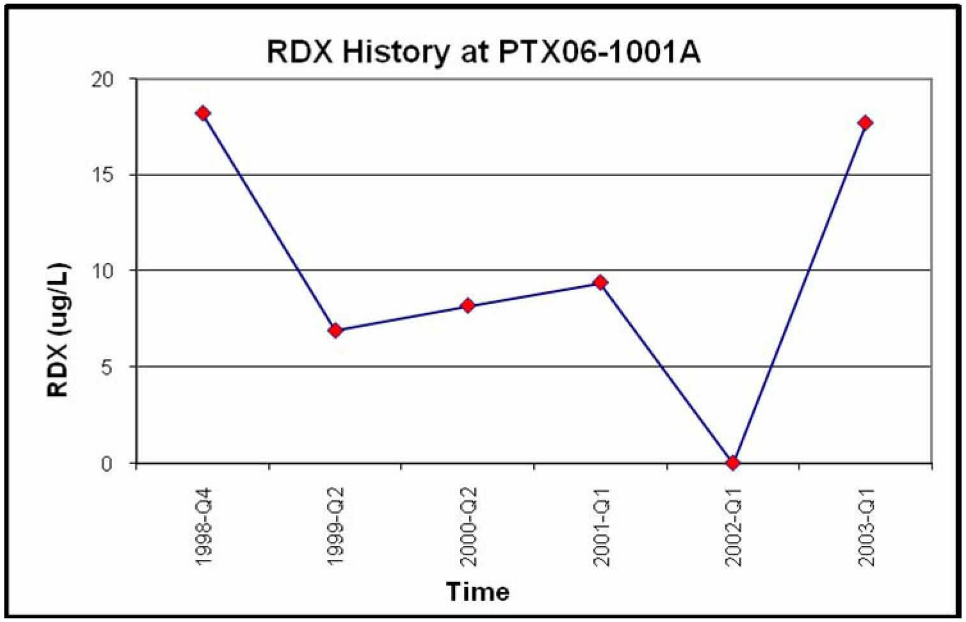

RDX at PTX08-1008
RDX (ug/L)
0.25
0.2
0.15
0.1
0.05
0
1998-Q3
1999-Q1
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2006-Q1
2007-Q1
2007-Q3
Time

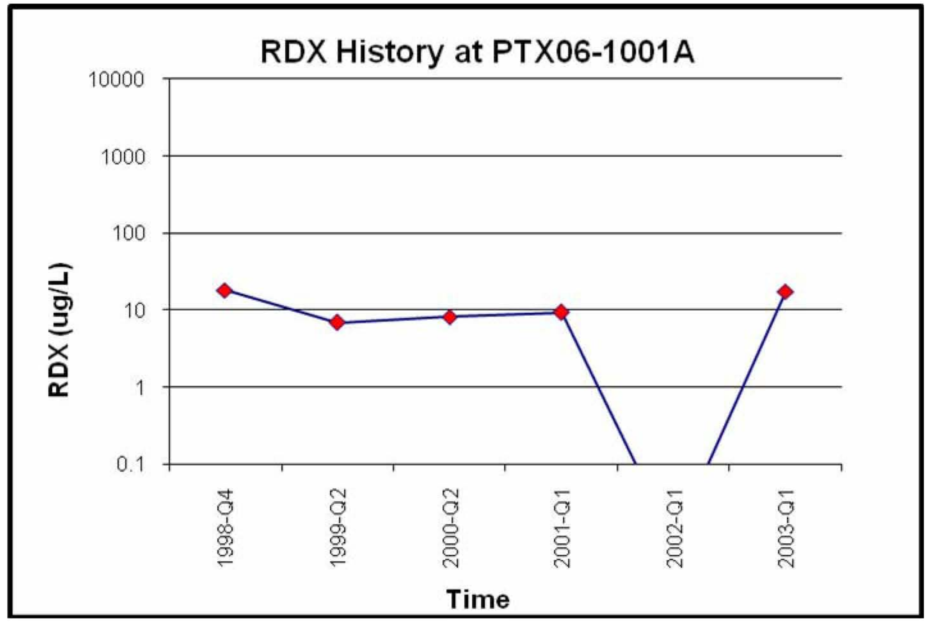

RDX at PTX08-1008
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q1
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2006-Q1
2007-Q1
2007-Q3
Time

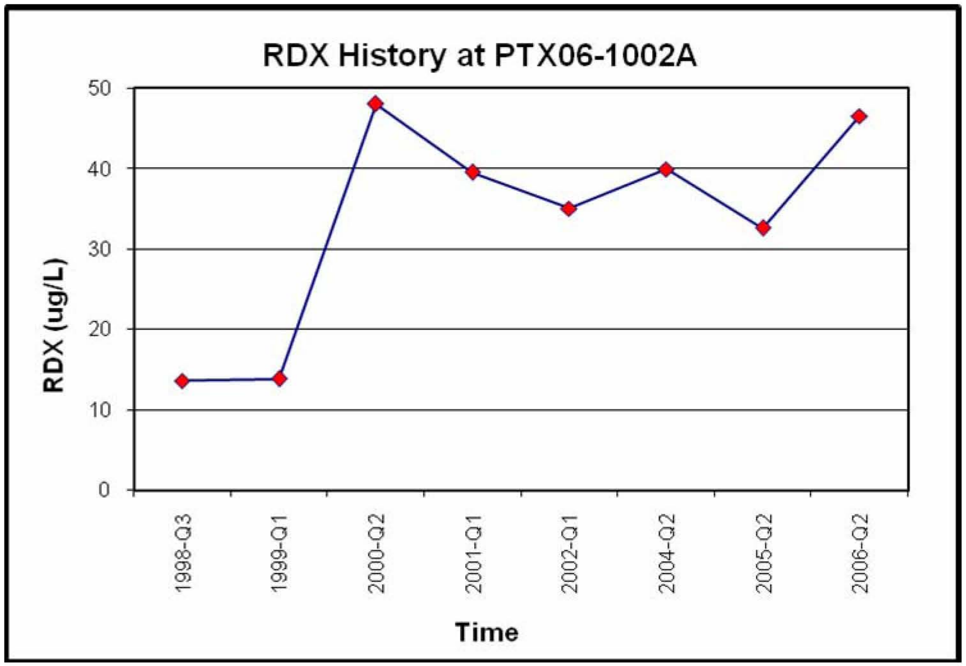

RDX History at PTX08-1009
RDX (ug/L)
40
30
20
10
0
1998-Q3
1999-Q1
2001-Q1
2002-Q1
2003-Q1
2004-Q2
2005-Q2
2006-Q2
Time

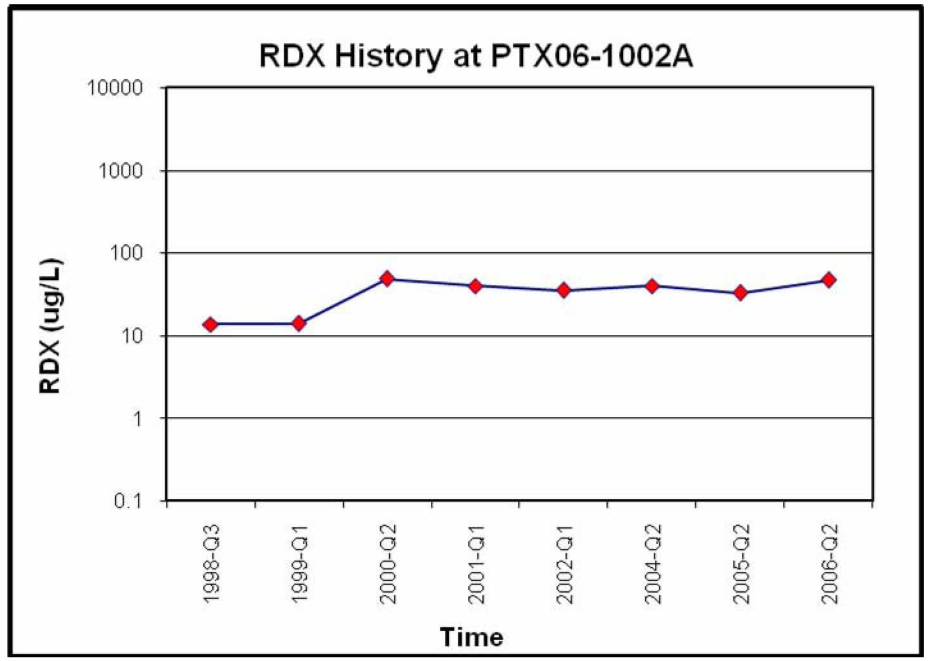

RDX History at PTX08-1009
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q1
2001-Q1
2002-Q1
2003-Q1
2004-Q2
2005-Q2
2006-Q2
Time

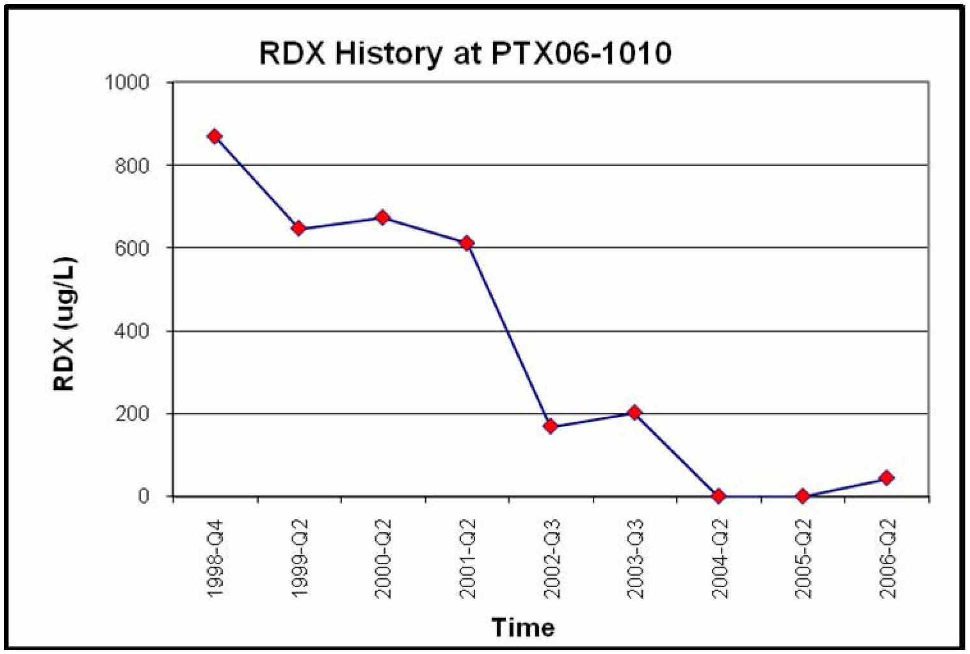
RDX histories for perched aquifer wells completed in the main body of perched groundwater, but more than 1000 feet from an extraction well

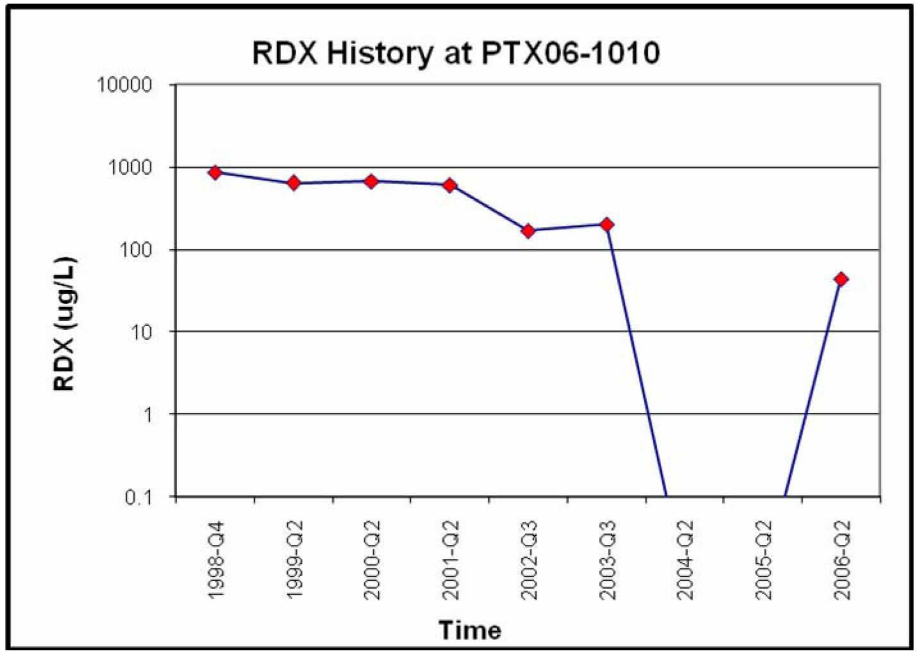

RDX History at PTX06-1001A
RDX (ug/L)
Time
0
5
10
15
20
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1

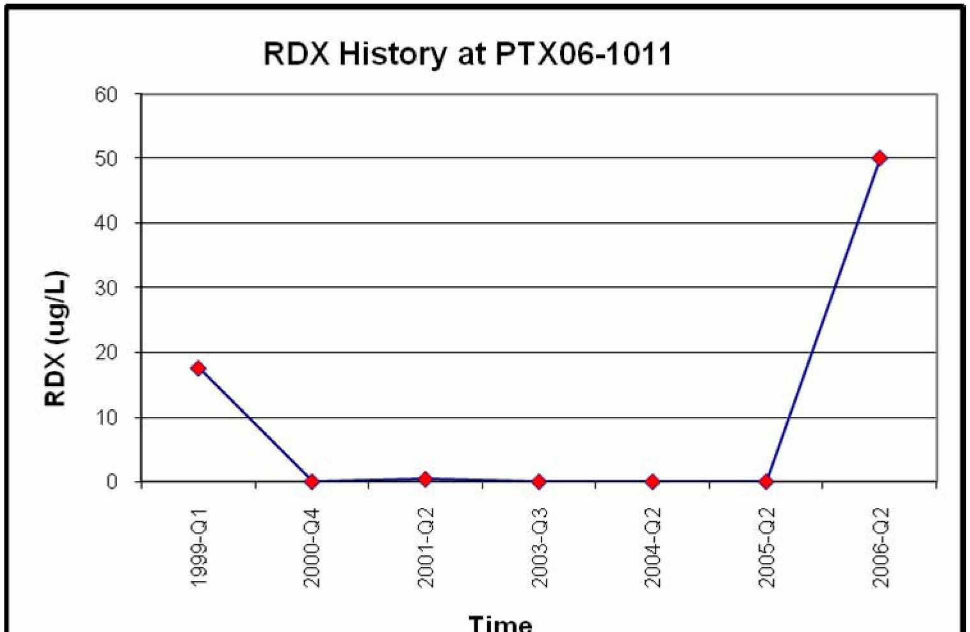

RDX History at PTX06-1001A
RDX (ug/L)
Time
0.1
1
10
100
1000
10000
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1

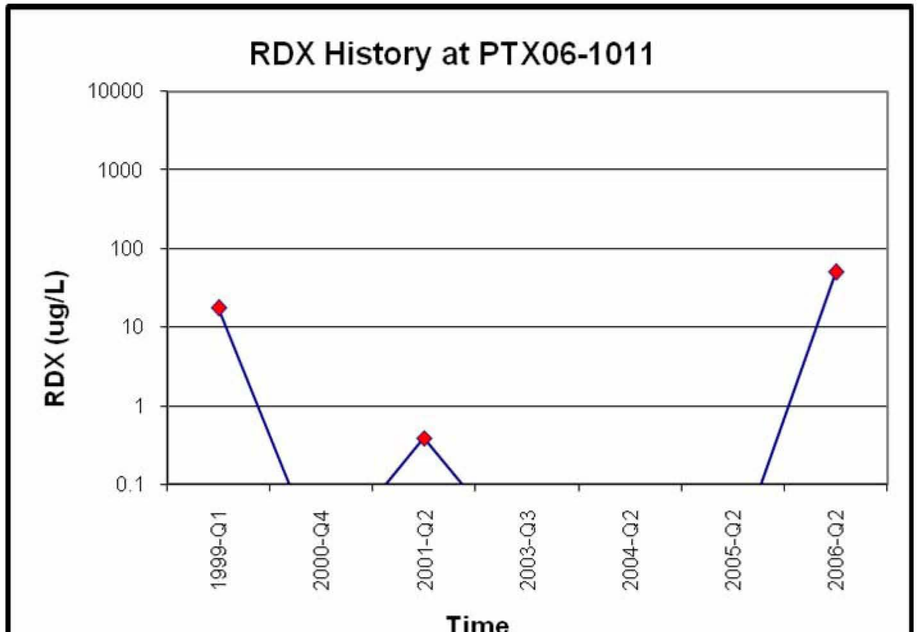

RDX History at PTX06-1002A
RDX (ug/L)
Time
0
10
20
30
40
50
1998-Q3
1999-Q1
2000-Q2
2001-Q1
2002-Q1
2004-Q2
2005-Q2
2006-Q2

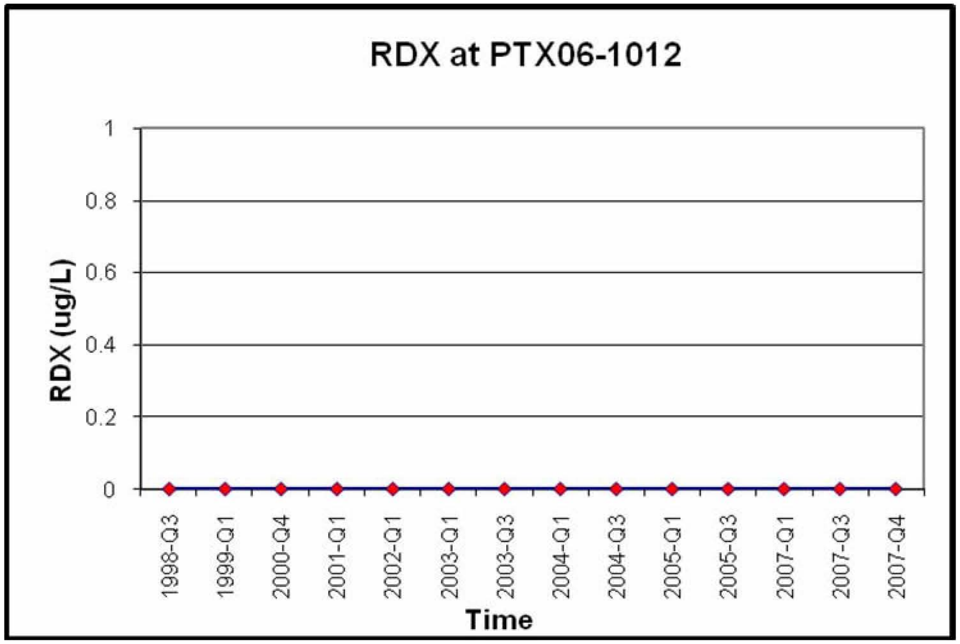

RDX History at PTX06-1002A
RDX (ug/L)
Time
0.1
1
10
100
1000
10000
1998-Q3
1999-Q1
2000-Q2
2001-Q1
2002-Q1
2004-Q2
2005-Q2
2006-Q2

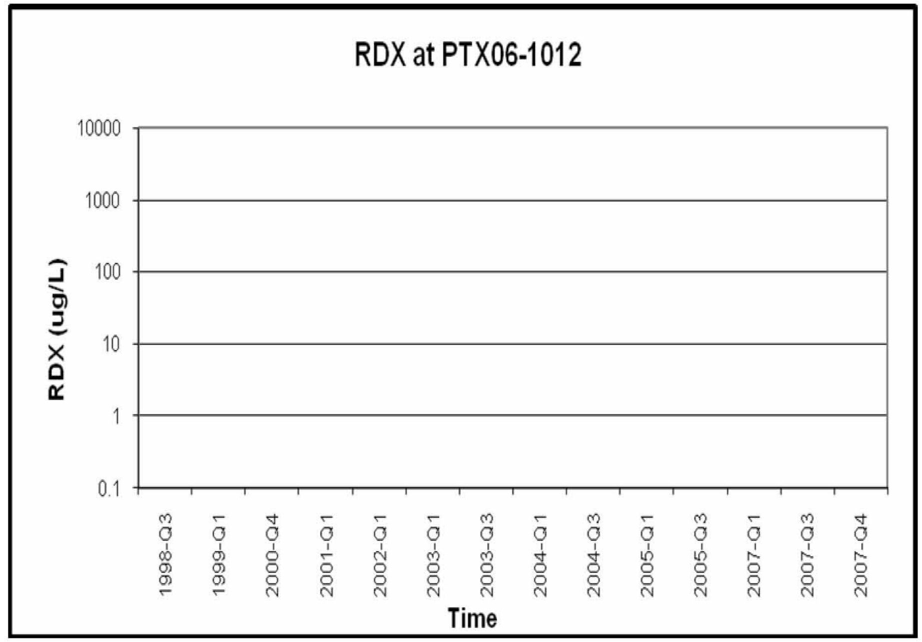

RDX History at PTX06-1010
1000
800
600
400
200
0
RDX (ug/L)
1998-Q4
1999-Q2
2000-Q2
2001-Q2
2002-Q3
2003-Q3
2004-Q2
2005-Q2
2006-Q2
Time

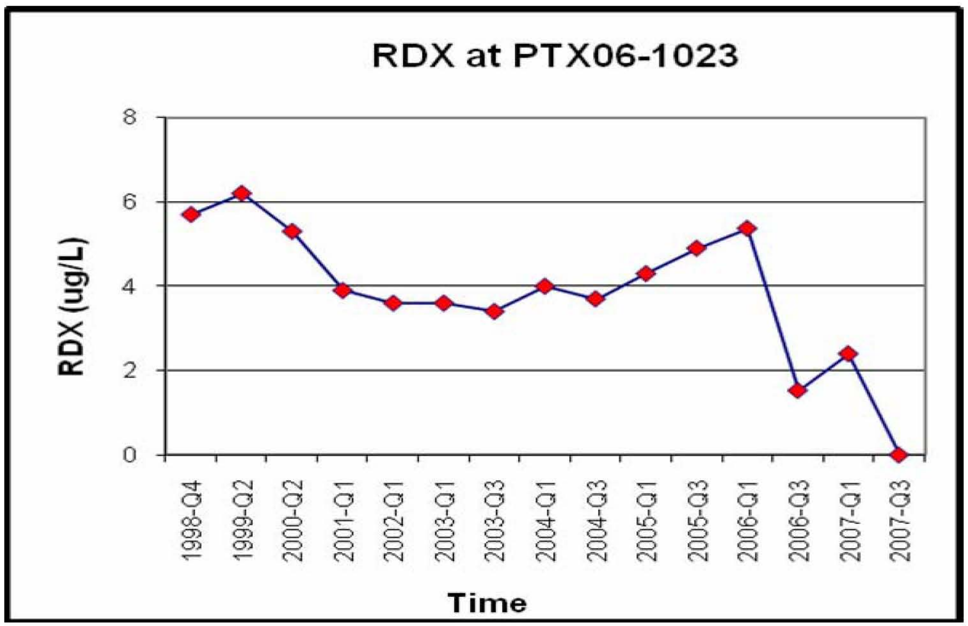

RDX History at PTX06-1010
10000
1000
100
10
1
0.1
RDX (ug/L)
1998-Q4
1999-Q2
2000-Q2
2001-Q2
2002-Q3
2003-Q3
2004-Q2
2005-Q2
2006-Q2
Time

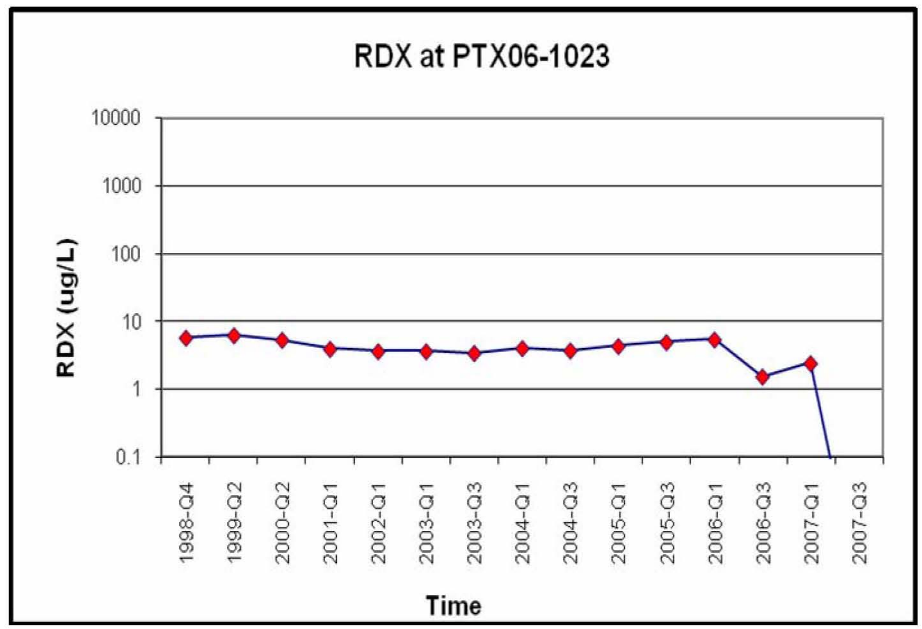

RDX History at PTX06-1011
60
50
40
30
20
10
0
RDX (ug/L)
1999-Q1
2000-Q4
2001-Q2
2003-Q3
2004-Q2
2005-Q2
2006-Q2
Time

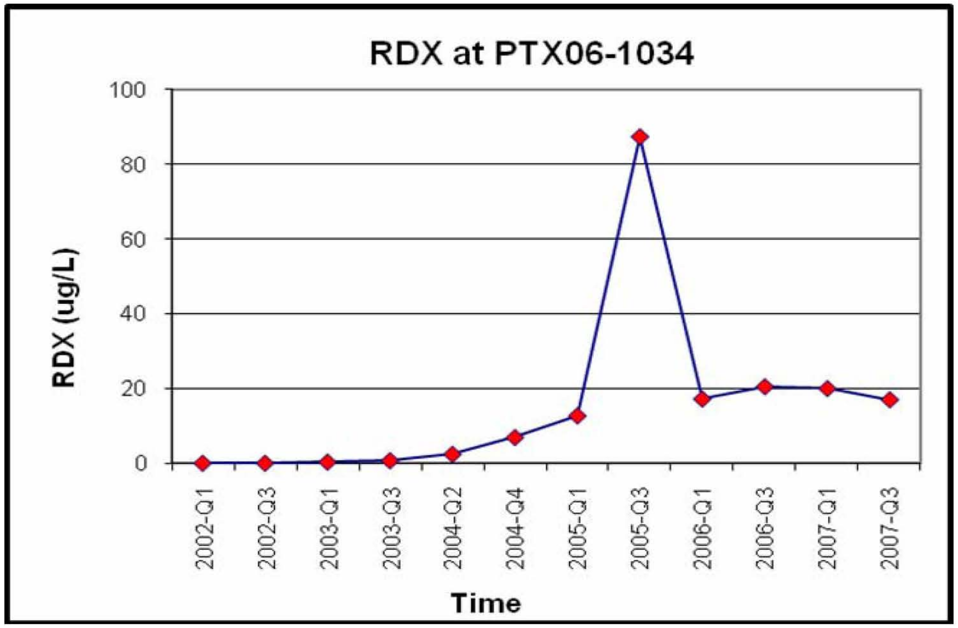

RDX History at PTX06-1011
10000
1000
100
10
1
0.1
RDX (ug/L)
1999-Q1
2000-Q4
2001-Q2
2003-Q3
2004-Q2
2005-Q2
2006-Q2
Time

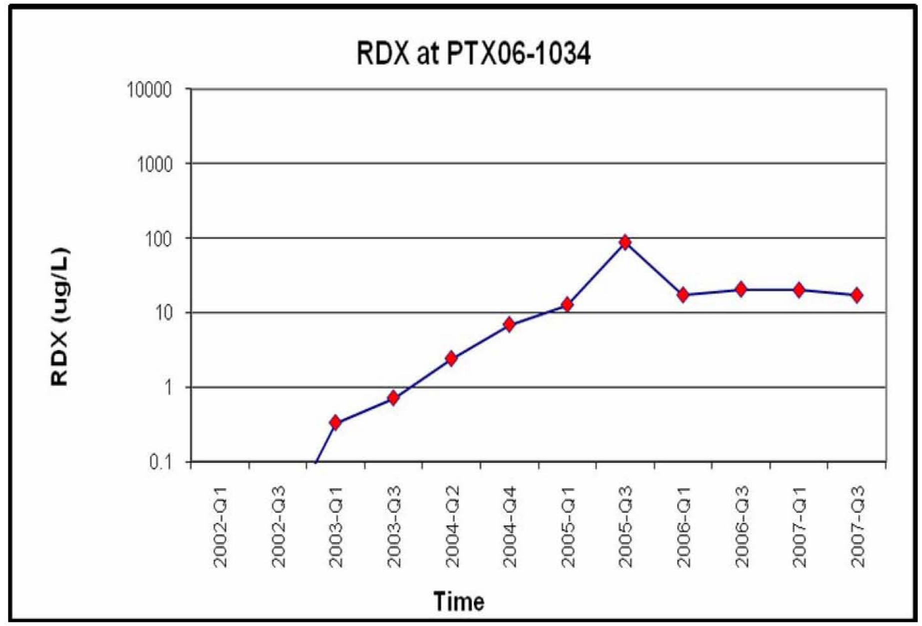

RDX at PTX06-1012
RDX (ug/L)
1
0.8
0.6
0.4
0.2
0
1998-Q3
1999-Q1
2000-Q4
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q1
2007-Q3
2007-Q4
Time

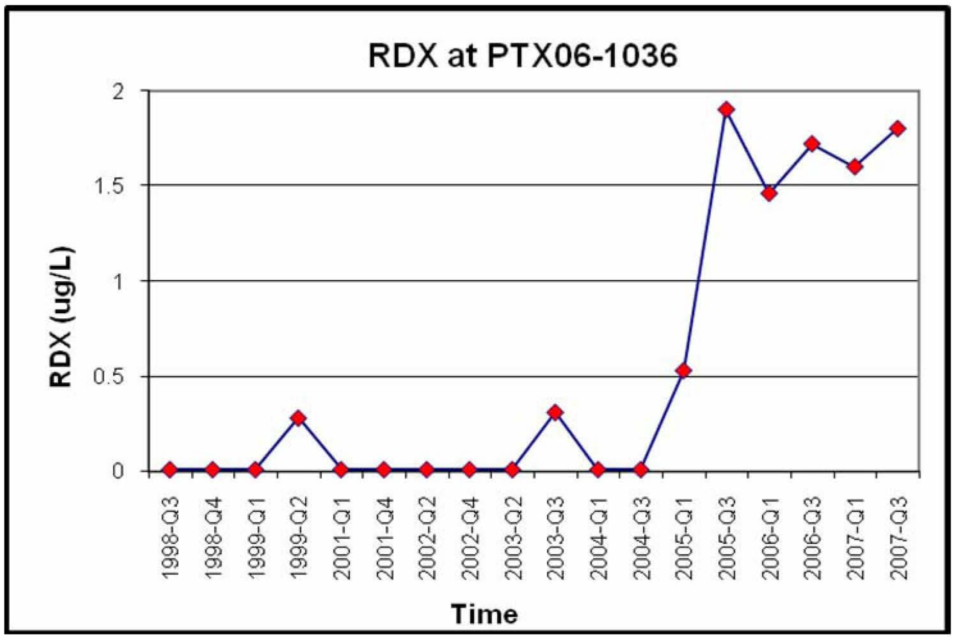

RDX at PTX06-1012
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
1999-Q1
2000-Q4
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q1
2007-Q3
2007-Q4
Time

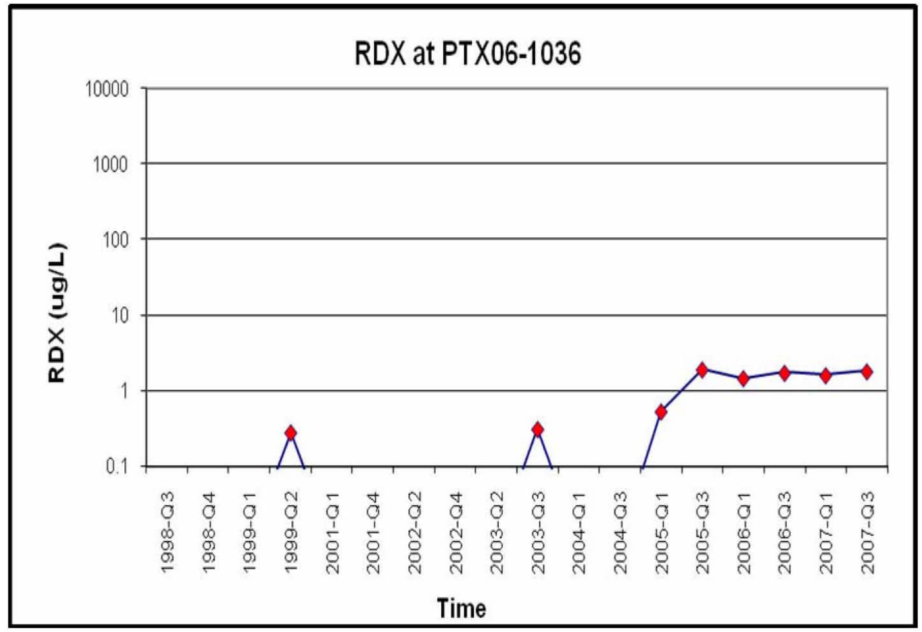

RDX at PTX06-1023
RDX (ug/L)
8
6
4
2
0
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

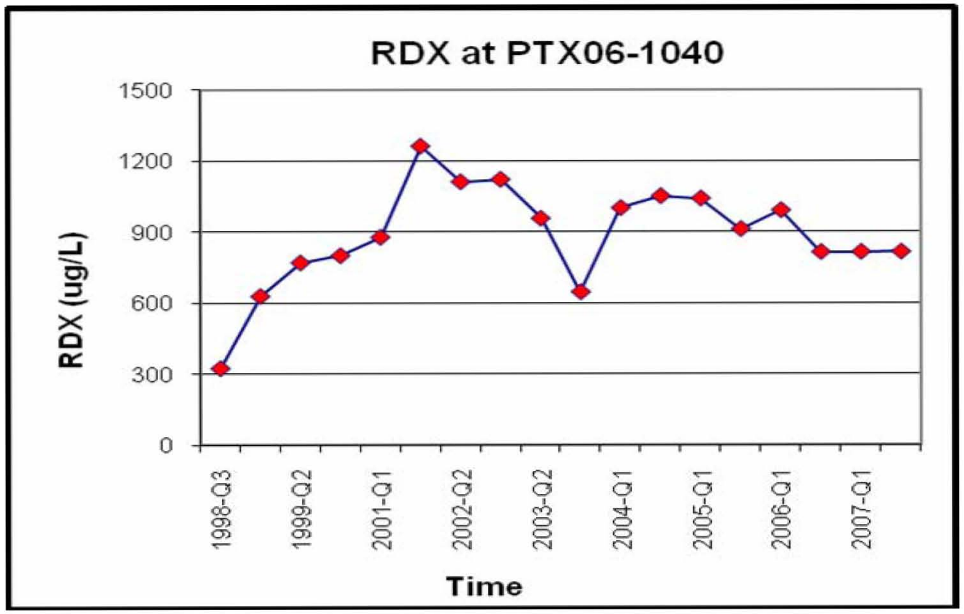

RDX at PTX06-1023
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q4
1999-Q2
2000-Q2
2001-Q1
2002-Q1
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

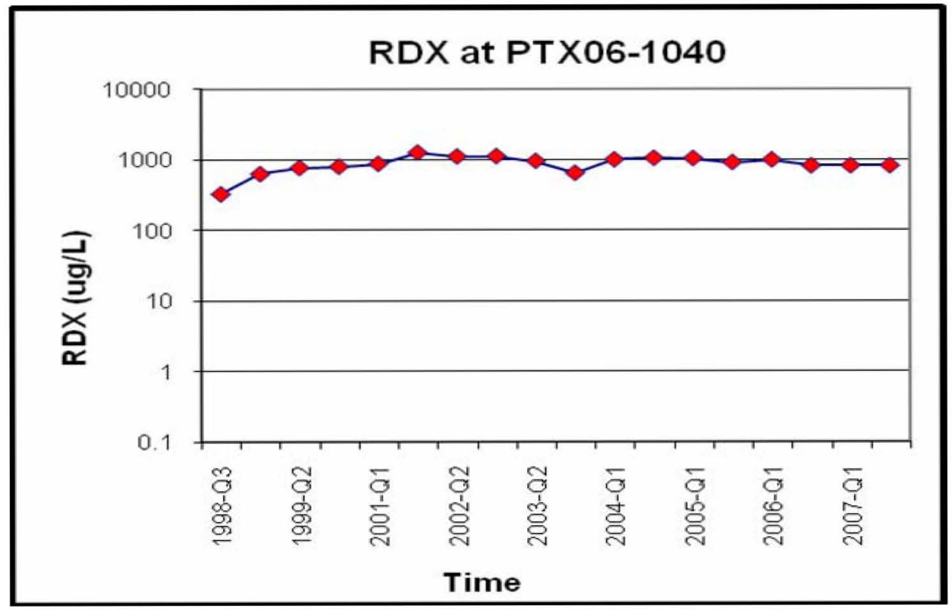

RDX at PTX06-1034
100
80
60
40
20
0
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q2
2004-Q4
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

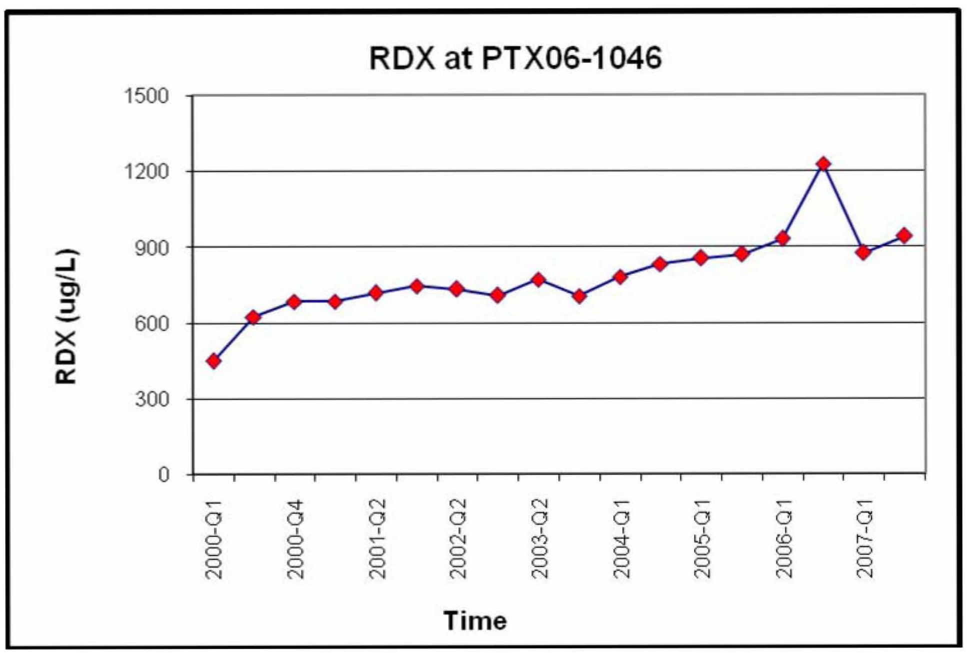

RDX at PTX06-1034
10000
1000
100
10
1
0.1
RDX (ug/L)
2002-Q1
2002-Q3
2003-Q1
2003-Q3
2004-Q2
2004-Q4
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

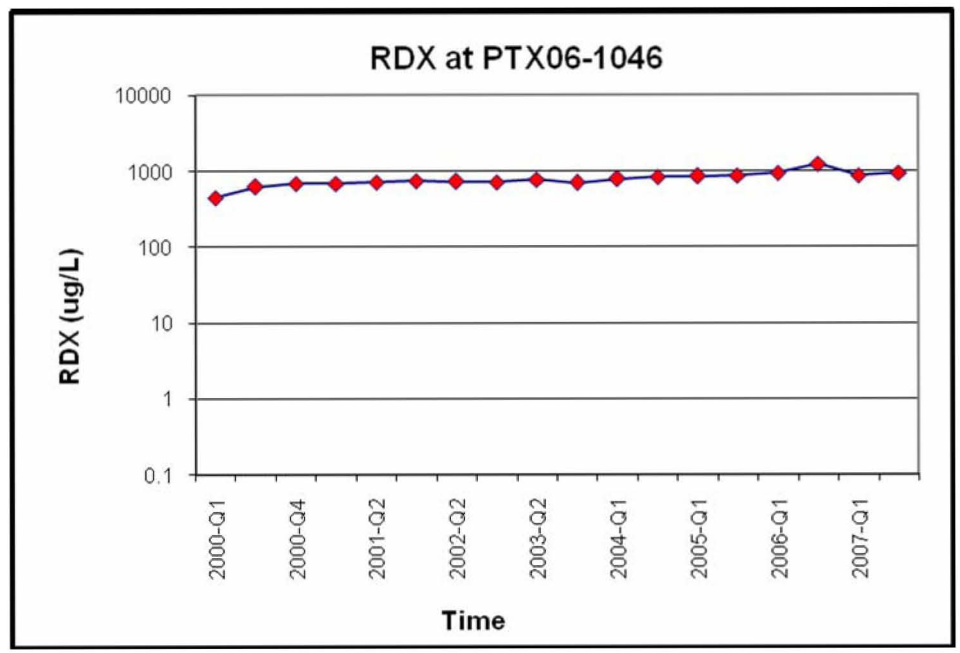

RDX at PTX06-1036
2
1.5
1
0.5
0
RDX (ug/L)
1998-Q3
1998-Q4
1999-Q1
1999-Q2
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

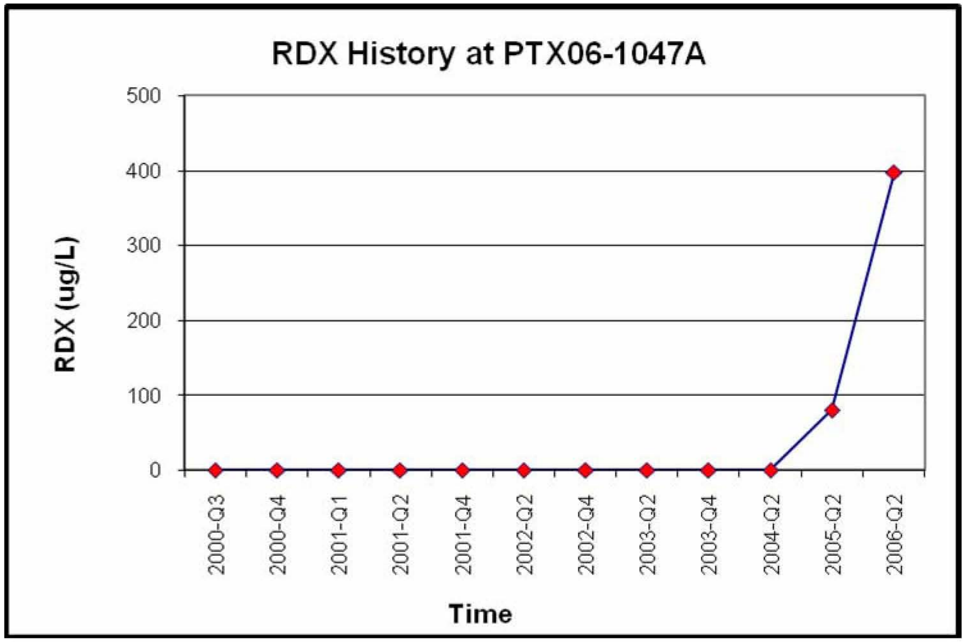

RDX at PTX06-1036
10000
1000
100
10
1
0.1
RDX (ug/L)
1998-Q3
1998-Q4
1999-Q1
1999-Q2
2001-Q1
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q1
2006-Q3
2007-Q1
2007-Q3
Time

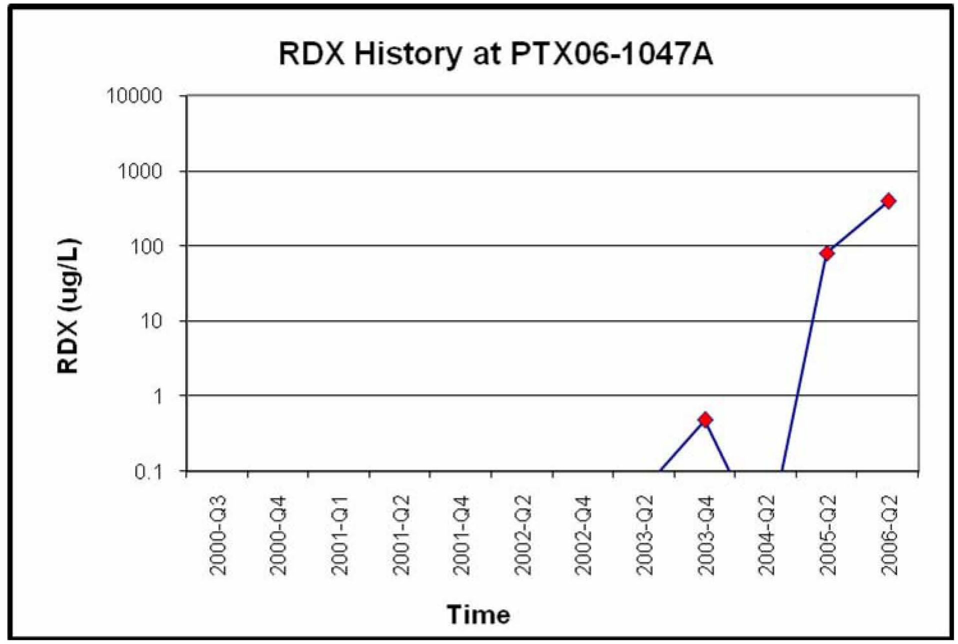

RDX at PTX06-1040
RDX (ug/L)
0
300
600
900
1200
1500
1998-Q3
1999-Q2
2001-Q1
2002-Q2
2003-Q2
2004-Q1
2005-Q1
2006-Q1
2007-Q1
Time

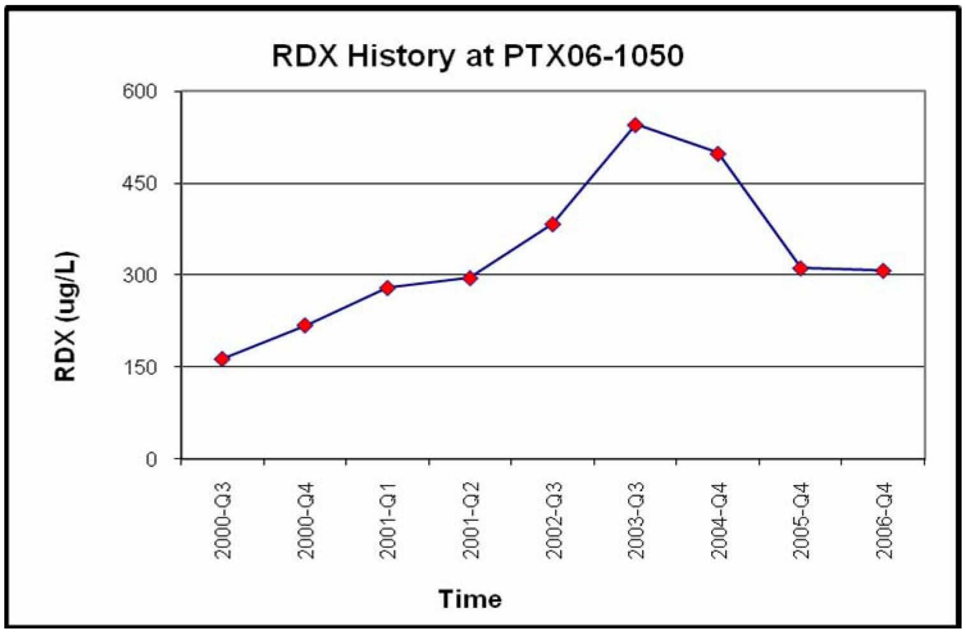

RDX at PTX06-1040
RDX (ug/L)
0.1
1
10
100
1000
10000
1998-Q3
1999-Q2
2001-Q1
2002-Q2
2003-Q2
2004-Q1
2005-Q1
2006-Q1
2007-Q1
Time

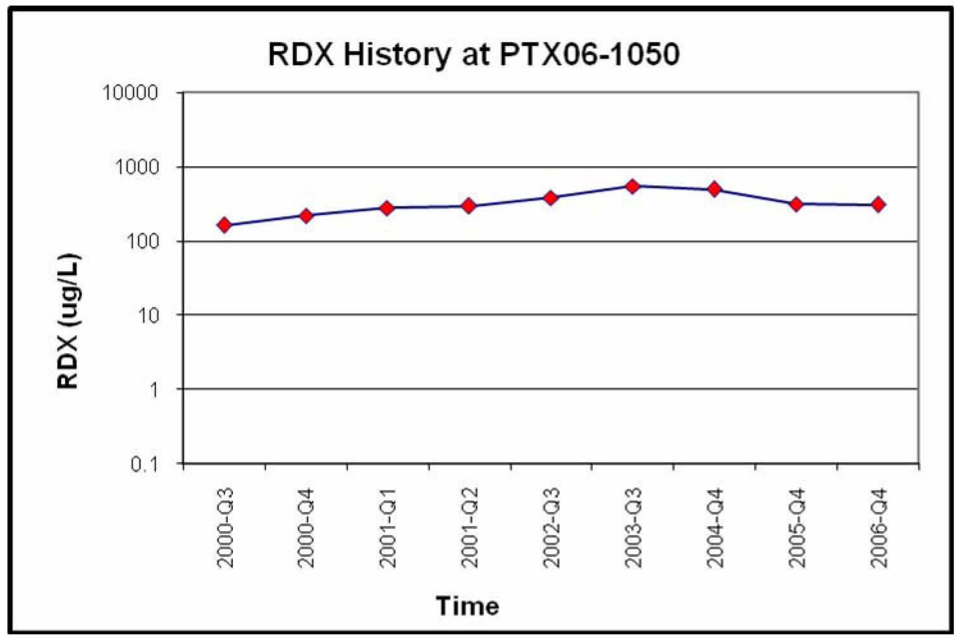

RDX at PTX06-1046
RDX (ug/L)
0
300
600
900
1200
1500
2000-Q1
2000-Q4
2001-Q2
2002-Q2
2003-Q2
2004-Q1
2005-Q1
2006-Q1
2007-Q1
Time

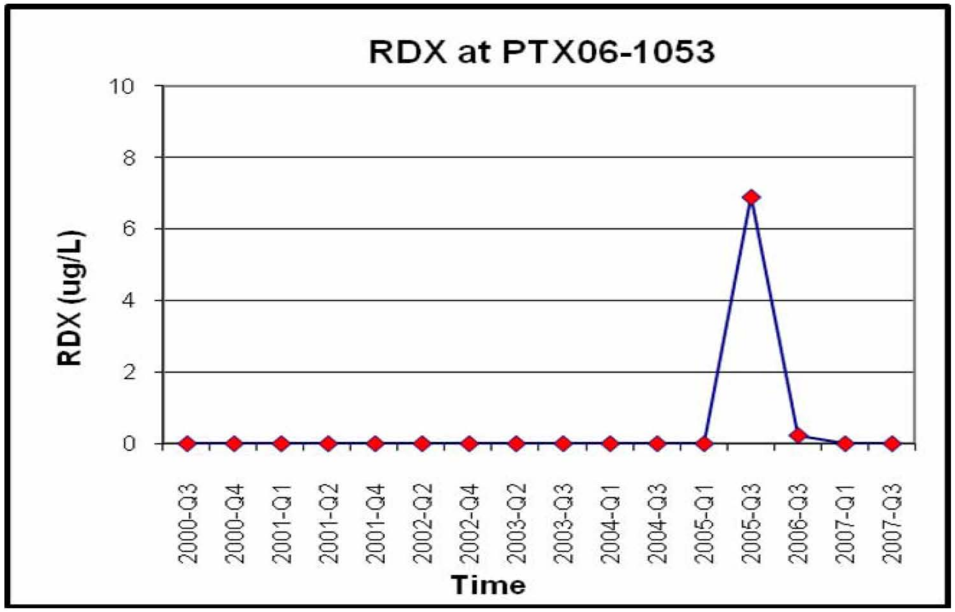

RDX at PTX06-1046
RDX (ug/L)
0.1
1
10
100
1000
10000
2000-Q1
2000-Q4
2001-Q2
2002-Q2
2003-Q2
2004-Q1
2005-Q1
2006-Q1
2007-Q1
Time

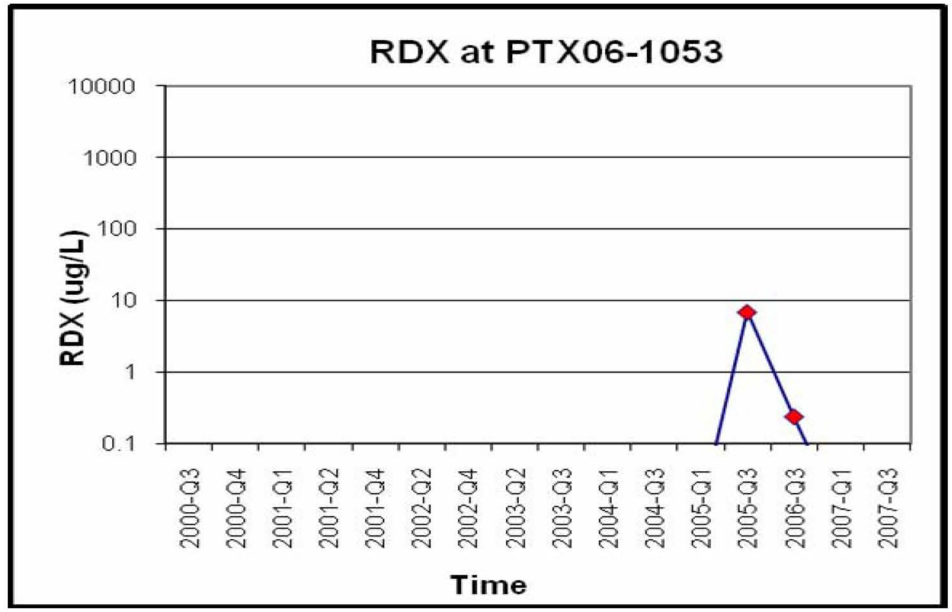

RDX History at PTX06-1047A
RDX (ug/L)
500
400
300
200
100
0
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q2
2005-Q2
2006-Q2
Time

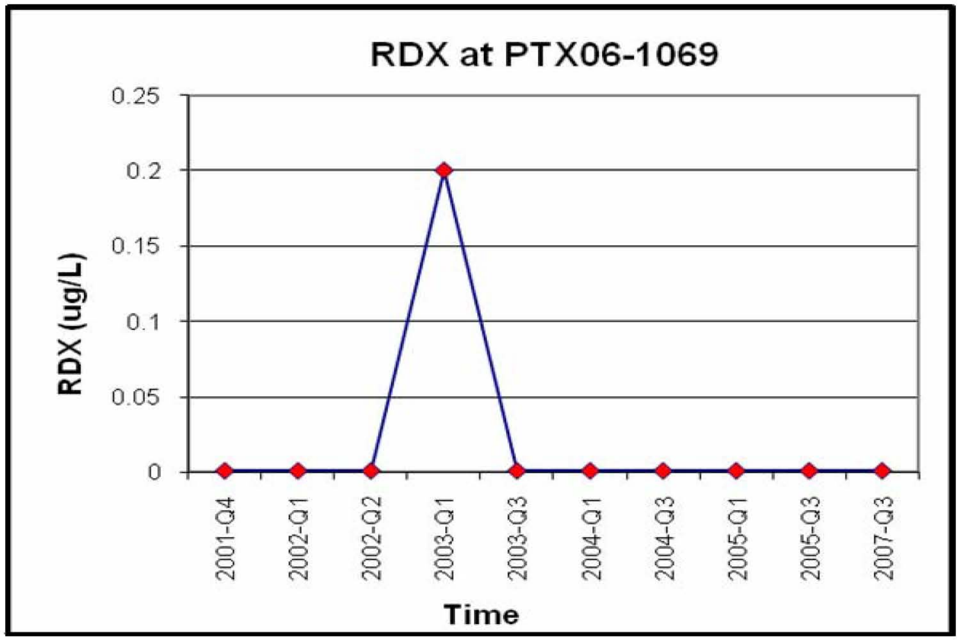

RDX History at PTX06-1047A
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q4
2004-Q2
2005-Q2
2006-Q2
Time

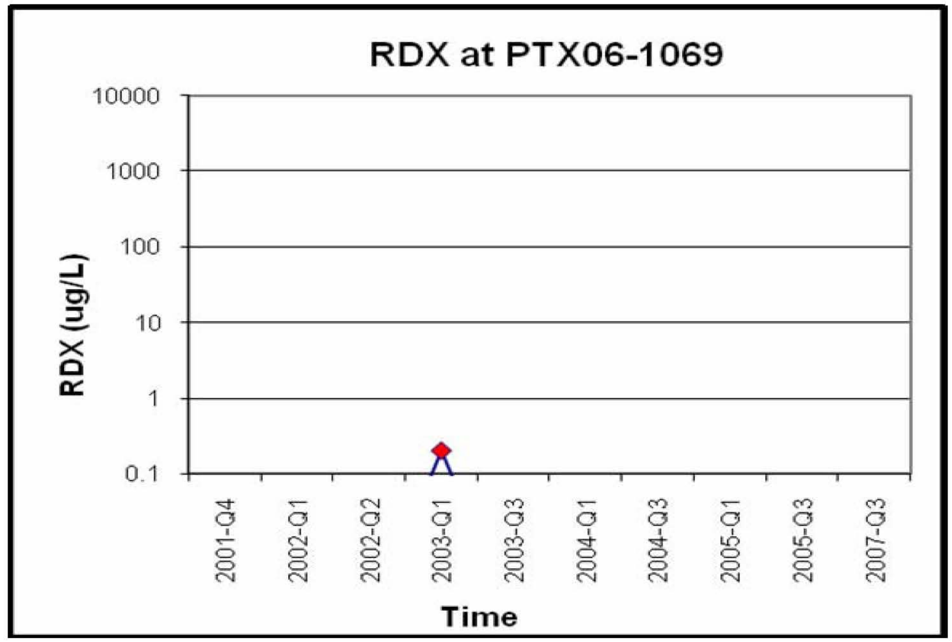

RDX History at PTX06-1050
RDX (ug/L)
600
450
300
150
0
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2002-Q3
2003-Q3
2004-Q4
2005-Q4
2006-Q4
Time

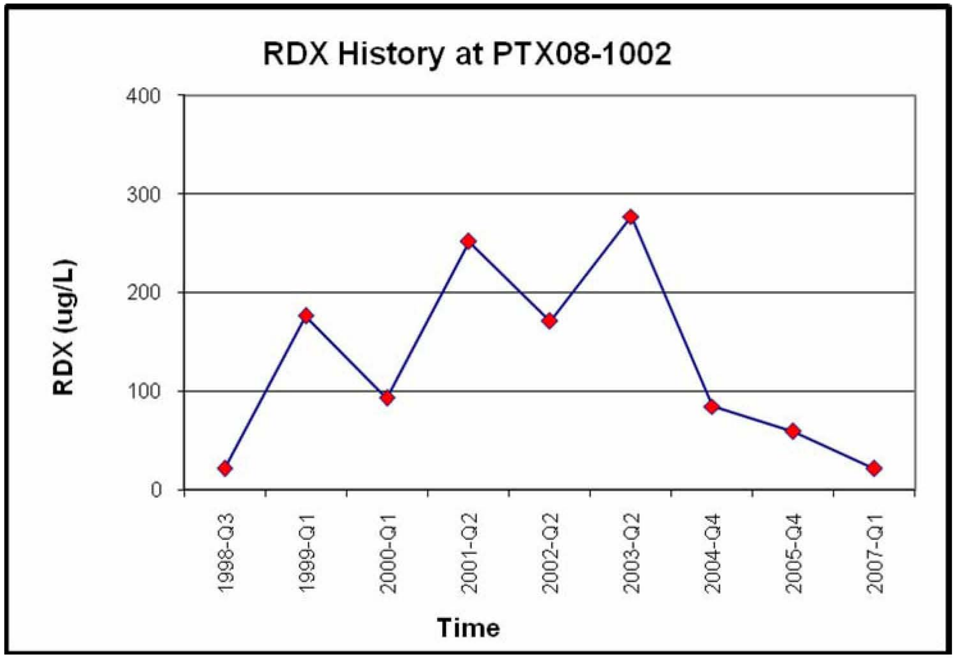

RDX History at PTX06-1050
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2002-Q3
2003-Q3
2004-Q4
2005-Q4
2006-Q4
Time

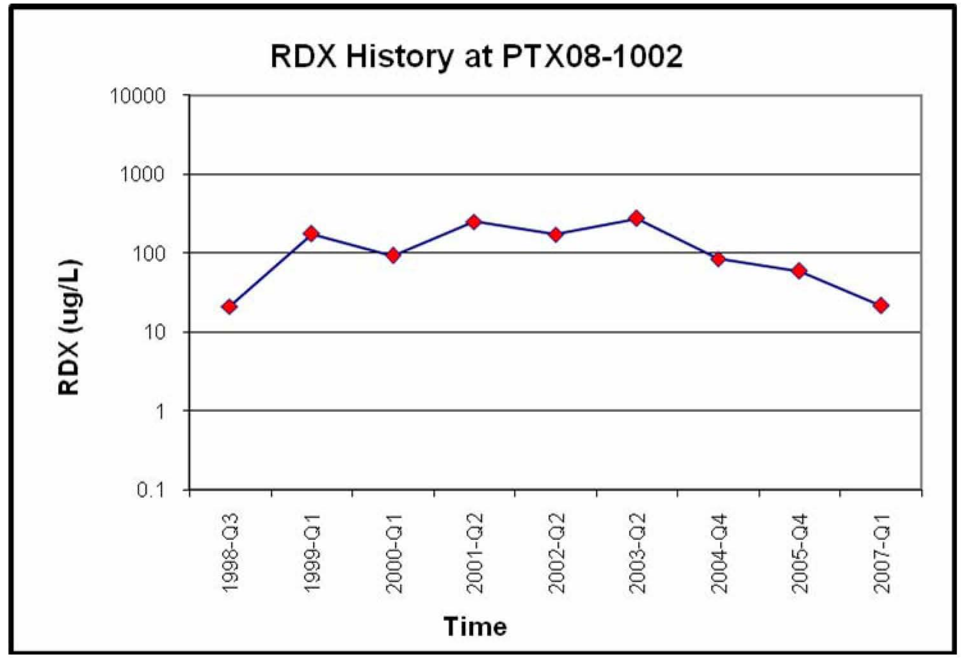

RDX at PTX06-1053
RDX (ug/L)
10
8
6
4
2
0
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q3
2007-Q1
2007-Q3
Time

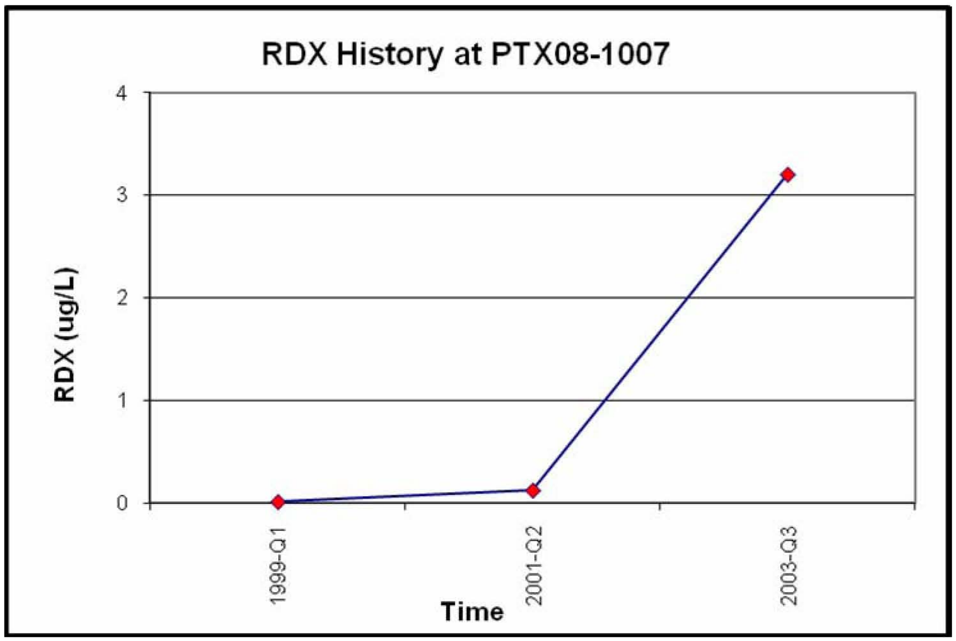

RDX at PTX06-1053
RDX (ug/L)
10000
1000
100
10
1
0.1
2000-Q3
2000-Q4
2001-Q1
2001-Q2
2001-Q4
2002-Q2
2002-Q4
2003-Q2
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2006-Q3
2007-Q1
2007-Q3
Time

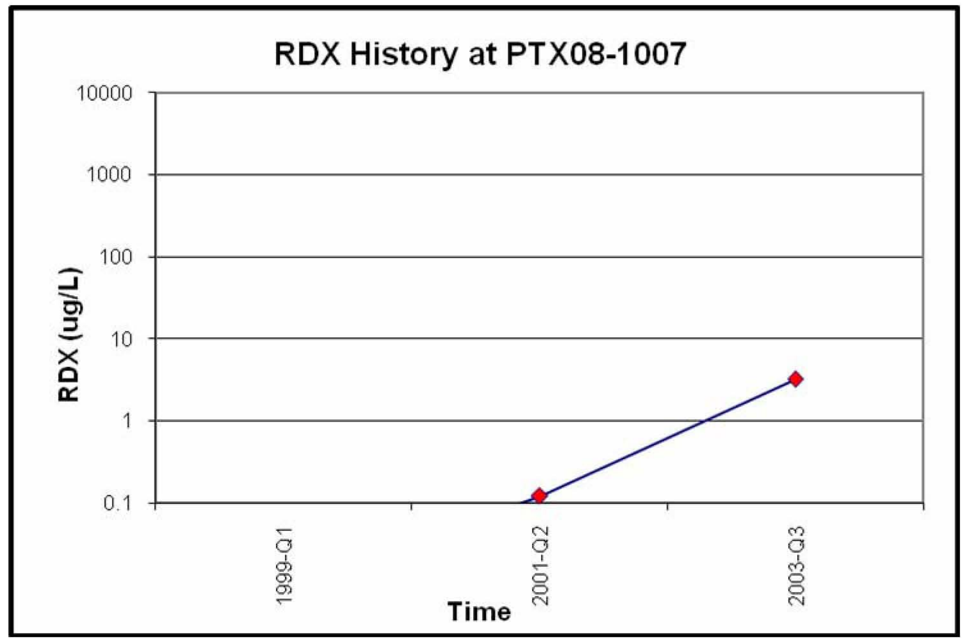

RDX at PTX06-1069
RDX (ug/L)
0.25
0.2
0.15
0.1
0.05
0
2001-Q4
2002-Q1
2002-Q2
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q3
Time

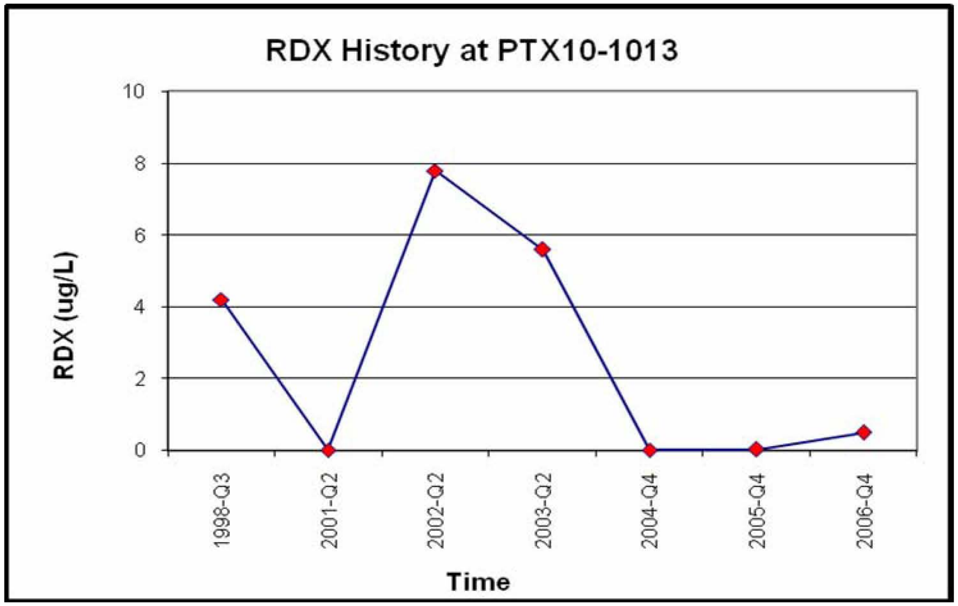

RDX at PTX06-1069
RDX (ug/L)
10000
1000
100
10
1
0.1
2001-Q4
2002-Q1
2002-Q2
2003-Q1
2003-Q3
2004-Q1
2004-Q3
2005-Q1
2005-Q3
2007-Q3
Time

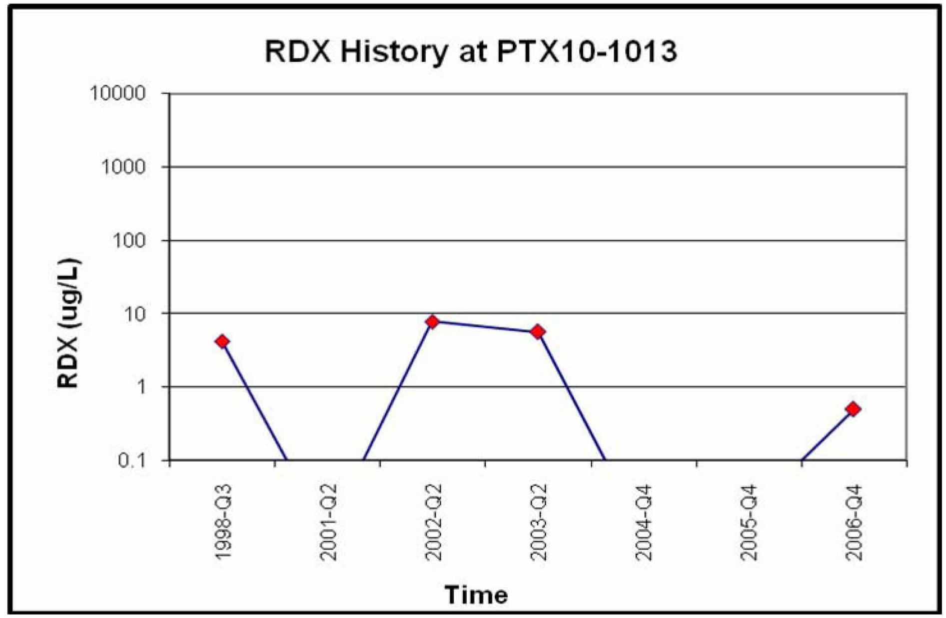

RDX History at PTX08-1002
400
300
200
100
0
RDX (ug/L)
1998-Q3
1999-Q1
2000-Q1
2001-Q2
2002-Q2
2003-Q2
2004-Q4
2005-Q4
2007-Q1
Time

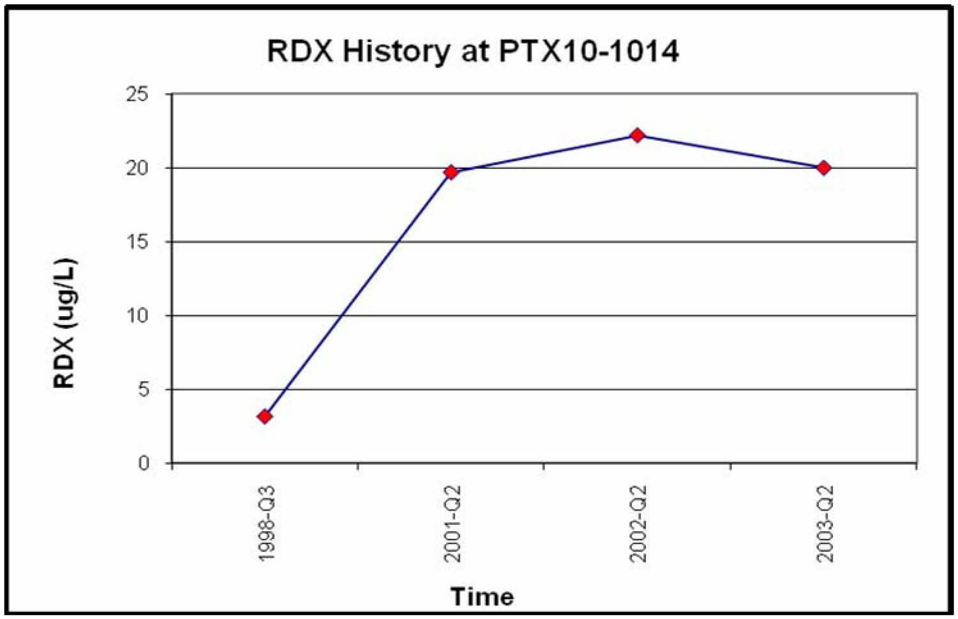

RDX History at PTX08-1002
10000
1000
100
10
1
0.1
RDX (ug/L)
1998-Q3
1999-Q1
2000-Q1
2001-Q2
2002-Q2
2003-Q2
2004-Q4
2005-Q4
2007-Q1
Time

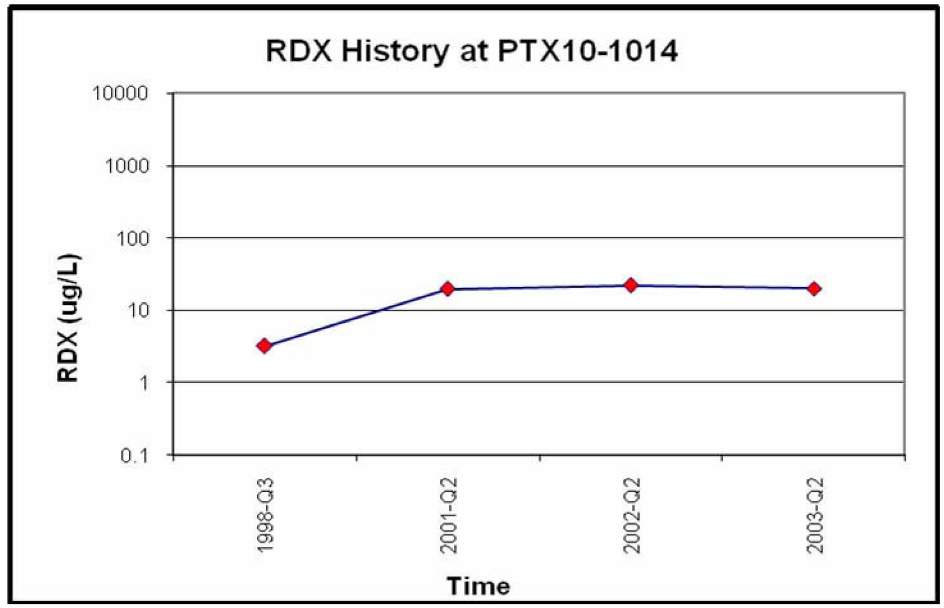

RDX History at PTX08-1007
4
3
2
1
0
RDX (ug/L)
1999-Q1
2001-Q2
2003-Q3
Time


RDX History at PTX08-1007
10000
1000
100
10
1
0.1
RDX (ug/L)
1999-Q1
2001-Q2
2003-Q3
Time


RDX History at PTX10-1013
RDX (ug/L)
10
8
6
4
2
0
1998-Q3
2001-Q2
2002-Q2
2003-Q2
2004-Q4
2005-Q4
2006-Q4
Time


RDX History at PTX10-1013
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
2001-Q2
2002-Q2
2003-Q2
2004-Q4
2005-Q4
2006-Q4
Time


RDX History at PTX10-1014
RDX (ug/L)
25
20
15
10
5
0
1998-Q3
2001-Q2
2002-Q2
2003-Q2
Time


RDX History at PTX10-1014
RDX (ug/L)
10000
1000
100
10
1
0.1
1998-Q3
2001-Q2
2002-Q2
2003-Q2
Time

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